DOCUMENT RESUME

ED 353 442	CE 062 875
AUTHOR	Fortney, Clarence; And Others
TITLE	Shielded Metal Arc Pipe Welding. Teacher Edition. Second Edition.
INSTITUTION	Mid-America Vocational Curriculum Consortium, Stillwater, Okla.
PUB DATE	92
NOTE	231p.; For related documents, see ED 341 786-787, ED 348 483, ED 348 487, and CE 062 874.
AVAILABLE FROM	Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, OK 74074-4364 (order no. CN600701).
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Behavioral Objectives; Classroom Techniques; Competence; Competency Based Education; Construction (Process); Course Content; Entry Workers; *Job Skills; Learning Activities; Lesson Plans; Maintenance; *Plumbing; Postsecondary Education; Secondary Education; Standards; Teaching Guides; Teaching Methods; Test Items; Transparencies; Units of Study; *Welding

ABSTRACT

This second edition of the shielded metal arc pipe welding curriculum guide presents both basic and advanced pipe welding skills. All specifications for procedure and welder qualification are presented according to national standards. The standards also include the test position for both groove and fillet pipe welding. The guide contains three units of instruction that cover the following topics: pipe welding orientation, safety, and equipment; print reading and layout for pipe welding; and pipe welding techniques and applications. Each instructional unit includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, student supplements, assignment sheets, and job sheets. A glossary of technical terms is also included. The unit components focus on measurable and observable learning outcomes and are designed for use in more than one lesson or class period. This teacher edition also contains information on the following: use of the publication; tools, materials, and equipment list; competency profile; instructional/task analysis; academic and workplace skill classifications and definitions; related academic and workplace skills list; and reference list. (KC)

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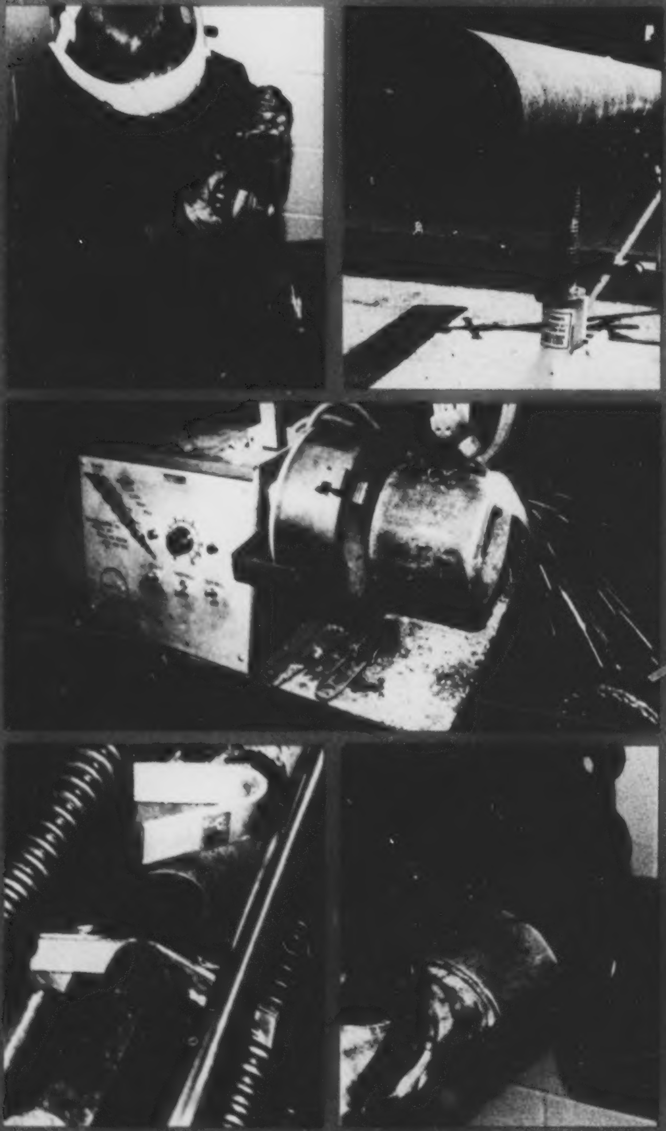
Shielded Metal Arc Pipe Welding

Second Edition



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- Safety and equipment
- Print reading and layout
- Techniques and applications

Teacher Edition

MAVCC

CE 062 875

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Shielded Metal Arc Pipe Welding

Second Edition

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93-009476

CN 600701

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Printed in the United States of America by the
Oklahoma Department of Vocational-Technical Education
Stillwater, OK 74074-4364

Mid-America Vocational Curriculum Consortium, Inc.
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Shielded Metal Arc Pipe Welding, Second Edition

Teacher Edition

Table of Contents

Foreword v
Acknowledgements vii
Use of introductory materials ix
Use of this publication xi
Academic and Workplace Skills Classification and Definitions xv
Competency profile xvii
Instructional/task analysis xix
Related Academic and Workplace Skills List xxiii
Tools, materials, and equipment list xxv
References xxvii

Unit 1: Pipe Welding Orientation, Safety, and Equipment 1

Unit 2: Print Reading and Layout for Pipe Welding 25

Unit 3: Pipe Welding Techniques and Applications 87

Foreword

Pipe welding is generally classified as transmission-line pipe welding or industrial pipe welding. However, pipe welding jobs come in all varieties. Pipe welding skills are still useful down on the farm, and good maintenance welders require good pipe welding skills.

Both basic and advanced pipe welding skills are presented in this second edition of *Shielded Metal Arc Pipe Welding*. Although a substantial amount of the original publication has been retained, all specifications for procedure and welder qualification are presented according to AWS standards. Those AWS standards also include the test position for both groove and fillet pipe welding. The changes and additions to the second edition are significant. Students who complete the activities in the instructional materials will certainly enhance their employability skills.

These instructional materials are designed not only for student use, but to assist teachers in improving instruction. Sequencing of components in the introductory materials and units of instruction are the biggest changes to be found in *Shielded Metal Arc Pipe Welding, Second Edition*. The written tests and transparency masters are no longer included in the student edition. Introductory materials include a competency profile to assist instructors in keeping accurate records of student competency gains. Other introductory materials include an instructional/task analysis, a tools and equipment list, a list of reference materials, and a summary of academic and workplace skills being reinforced in the text.

Special attention should be given to the teacher suggestions in each unit of instruction. These suggestions present ways to increase reinforcement of academic and workplace basic skills. By reinforcing these skills, the instructor will assist students in improving their employability skills.

As you use these instructional materials, we hope you find they contribute to the quality of your program. We feel you will appreciate the technical changes in the second edition, and the streamlined format in which it is presented. Every effort has been made to make these materials readable and by all means useable. You, as an instructor, will need to develop instructional strategies for localizing, individualizing, and supplementing the text. Most of all, you need to motivate the students who use the materials.

As always, MAVCC appreciates hearing from people who use our publications. Please write or call MAVCC and share your opinions about *Shielded Metal Arc Pipe Welding, Second Edition*. Tell us what you liked and/or what you think needs to be changed. We want to hear from you.

Mervin Birdwell, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

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Acknowledgements

The contents of this publication reflect the input of a planning and validation committee that met to help revise and expand the Mid-America Vocational Consortium welding series. For their professional help with *Shielded Metal Arc Pipe Welding, Second Edition*, we extend a thank you to:

Larry New	Metal Testing Instructor, Pulaski Technical College, North Little Rock Arkansas
Dave Roberts	Sales Manager, Majestic Metals, Denver, Colorado
Roger Pint	Owner, Winthrop Welding Works, Winthrop, Iowa
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Joe Don Davidson	President, Oklahoma Joe's, Perry, Oklahoma
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Additional thanks go to the manufacturers and suppliers whose procedures and graphic materials have enhanced this text. A special thank you to the American Welding Society for their materials and assistance.

And finally to the Oklahoma Department of Vocational and Technical Education, a thank you to personnel in wordprocessing, art, and the print shop for their help in developing and printing a fine text.

Use of Introductory Materials

Introductory materials are included in the teacher guide only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information such as the table of contents, foreword, and acknowledgements page, information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/ learning process.

2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.

3. **Instructional/task analysis**—Provides a quick review of contents of the publication; identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.

4. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills being reinforced. Skill areas reflected by skill groups, sub skills, and descriptions have been identified using *Workplace Basics: The Skills Employers Want*, developed by the American Society for Training and Development (ASTD) and the U.S. Department of Labor and adapted by MAVCC.

5. **Tools, equipment, and materials list**—Provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.

6. **Reference list**—Provides a comprehensive list of resources used in the development of this publication.

A glossary of terms may also be provided in the introductory materials depending on subject matter and committee recommendations.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

Shielded Metal Arc Welding, Second Edition contains three units of instruction. Each instructional unit in a teacher guide includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, assignment sheets, student supplements, and job sheets.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Objective sheet (Color code: White)

Each unit of instruction is based on performance objectives which state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives which state the expected performance of each student after completion of the unit of instruction, and specific objectives which state what the student must do to reach the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested activities (Color code: Pink)

This component is included only in the teacher guide. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teacher suggestions, and skill areas have been noted in bold. (A table of academic and workplace skills with accompanying definitions has been provided on page xv.) The teacher should read the suggested activities before teaching the units and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Instructions for evaluating student performance on the job sheets are also included in the suggested-activities section. Teachers should select and discuss with students the rating scale that will be used.

Assignment and written test answers (Color code: Pink)

Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluation of student performances.

Written test (Color code: Yellow)

This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction. The test appears in the teacher guide only, but duplication is permitted for student use. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

Unit evaluation form (Color code: White)

This sheet provides teachers with a record of each students performance on a unit of instruction. It includes space for assignment sheet ratings, job sheet ratings, written test scores, and teacher comments. The unit evaluation form is included in the teacher guide only, but may be duplicated.

Use of This Publication

Teacher supplements (Color code: White)

This component is included only in the teacher guide. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters (Color code: White)

Transparencies are included in the teacher guide only and are used to direct the students' attention to the topic of discussion. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Information sheet (Color code: Green)

The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements (Color code: White)

Student supplements are included in the student manual. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment sheets or job sheets.

Assignment sheets (Color code: Tan)

Assignment sheets provide students with pencil and paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets (Color code: Blue)

The job sheets provide criteria to objectively evaluate student performance, a list of required equipment and materials, and a step-by-step procedure for performing a psychomotor skill. The teacher should discuss the equipment and materials available in the classroom and/or laboratory and demonstrate the procedure prior to having students practice procedure. When a student is ready to be evaluated, the teacher should follow instructions for evaluating student performance which may be found in the teacher guide.

Job sheets are an important segment of each unit. Job sheets provide potential employers with a picture of the skills being taught during training and the performances that might reasonably be expected from an individual who has had this training.

Disseminating material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder or folder for the current unit of study. This is convenient for students taking the material home to study. Upon completion, each unit is then placed in a larger binder. Some teachers prefer to store the material by unit in filing cabinets or boxes until needed.

For best results, provide student materials for each student. Student manuals contain objective sheets, information sheets, student supplements, assignment sheets, and job sheets. Students should be allowed to take their materials home at the end of the course.

Academic and Workplace Skills
(Classifications and Definitions)

Skill Groups	Sub Skills	Definitions
Learning Skills	Learning to learn	Developing ability to apply knowledge to other situations; knowing how to learn.
Foundation Skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea or fact in written form in a clear, concise manner.
	Math	Applying computation skills such as reasoning, estimation, and problem solving as they are actually used on the job.
	Science	Applying knowledge learned through study or practice that is based on scientific principles as they relate to specific tasks.
Communication Skills	Listening	Listening for content, conversation, long-term contexts, emotional meaning, and directions.
	Oral communication	Communicating a thought, idea, or fact in spoken form in a clear, concise manner.
Adaptability Skills	Creative thinking	Using imagination to create something new—i.e. an idea, invention, work of art.
	Problem solving (critical thinking)	Recognizing and defining problems, inventing, and implementing solutions, and tracking and evaluating results.
Personal Management Skills	Self-esteem	Developing self-confidence and creating a positive self-image.
	Motivation/goal setting	Setting and meeting defined goals and objectives.
	Personal and career development	Emphasizing self-direction by establishing and implementing a plan.
Group Effectiveness Skills	Interpersonal relations	Developing ability to maintain positive relations with others.
	Negotiation	Resolving conflict between two or more individuals.
	Teamwork	Working together in a group to reach a common goal.
Influence Skills	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Leadership	Directing/influencing group in performance of a specific task; accepting responsibility for others.

Competency Profile

Name: ______________________________

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focused on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Option A

Rating scale:
4 - Skilled - Can perform job with no additional training.
3 - Moderately Skilled - Has performed job during training program; limited additional training may be required.
2 - Limited Skill - Has performed job during training program; additional training is required to develop skill.
1 - Unskilled - Is familiar with process, but is unable to perform job.
0 - No Exposure - No information or practice provided during training program, complete training required.
NA - Non-applicable.

Option B

Yes - Can perform with no additional training
No - Is unable to perform satisfactorily

Unit 1: Pipe Welding Orientation, Safety, and Equipment

______1. Solve problems about pipe welding qualification.
______2. ______________________________

______Written Test Score

Unit 2: Print Reading and Layout for Pipe Welding

______1. Solve trigonometry problems for unknown sides.
______2. Solve trigonometry problems for unknown angles.
______3. Develop a template for a two-piece 90° turn.
______4. Develop a template for a 90° branch with pipes of equal size.
______5. Develop a template for a 45° branch connection.
______6. ______________________________

______Written Test Score

Unit 3: Pipe Welding Techniques and Applications

______1. Bevel and prepare pipe for welding.
______2. Weld to specifications a V-groove butt joint on 6" schedule 40 pipe in the horizontal position.
______3. Conduct root- and face-bend tests and a nick-break test on welded pipe.

______4. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up position.

______5. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up, 45° inclined position.

______6. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down position.

______7. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down, 45° inclined position.

______8. ______________________________

______Written Test Score

COMMENTS: ______________________________

____

____

____

____

Evaluator: ______________________ Date: ______________

*** Permission to duplicate this profile is granted.**

Shielded Metal Arc Pipe Welding, Second Edition

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 1: Pipe Welding Orientation, Safety, and Equipment

1. Terms and definitions
2. Transmission-line pipe welding and industrial pipe welding
3. Characteristics of transmission-line pipe welding
4. How a cross-country pipe welding crew operates
5. API classifications for transmission-line pipe
6. Characteristics of industrial pipe welding
7. Classifications for industrial pipe
8. Welding skills required for good pipe welding
9. Organizations that set pipe and pipe welding standards
10. AWS positions for groove pipe welding
11. AWS positions for fillet pipe welding
12. AWS guidelines for G-position qualification
13. AWS guidelines for F-position qualification
14. Guidelines for pipe welding safety
15. Pipe welding situations that require special attention

Related Information: What the Student Should Know

16. Special precautions for pipe welding hot lines
17. Types of line-up clamps and their characteristics
18. Characteristics of pipe beveling machines
19. Jack stands and their uses
20. Center finders and their uses
21. Types of contour markers
22. Wrap-arounds and their uses
23. Templates and their uses
24. Other pipe welding tools and their uses

Application: What the Student Should Be Able to Do

25. Solve problems about pipe welding qualification (Assignment Sheet 1)

Unit 2: Print Reading and Layout for Pipe Welding

1. Terms and definitions
2. Methods for presenting pipe on prints
3. Pipe symbols and their uses
4. Common pipe symbols and their meanings
5. Methods of dimensioning prints for pipe welding
6. Symbols for common pipe fittings
7. Special welded fittings and their uses
8. Advantages of isometric drawings for pipe welding prints
9. Functions of a right triangle

Related Information: What the Student Should Know

10. Steps in solving trigonometric problems
11. Steps in laying out angles on 90° long radius elbows
12. 12-inch rule for finding angles with a steel square
13. Standard references for commercial pipe identification
14. Standard weld fittings and their shapes

Application: What the Student Should Be Able to Do

15. Solve trigonometry problems for unknown sides (Assignment Sheet 1)
16. Solve trigonometry problems for unknown angles (Assignment Sheet 2)
17. Develop a template for a two-piece 90° turn (Job Sheet 1)
18. Develop a template for a 90° branch with pipes of equal size (Job Sheet 2)
19. Develop a template for a 45° branch connection (Job Sheet 3)

Unit 3: Pipe Welding Techniques and Applications

1. Terms and definitions
2. Guidelines for beginning pipe welders
3. AWS classifications for mild steel and alloy electrodes
4. Electrode selection for pipe welding
5. Joint preparation, fit-up, and alignment
6. Guidelines for joint dimensioning
7. Guidelines for joint preparation
8. Common methods of pipe alignment
9. Common problems in pipe welding and their causes
10. Pipe welding troubleshooting chart
11. Ways to prevent pipe welds from cracking
12. The concept of quartering

Related Information: What the Student Should Know

13. Qualification procedures for pipe welding
14. Qualification testing and its importance in pipe welding
15. Methods of pipe inspection
16. Specimen locations for AWS welding procedure qualification
17. AWS specifications for specimen preparation
18. API procedure qualification
19. Specimen locations for AWS welder qualification

Application: What the Student Should Be Able to Do

20. Bevel and prepare pipe for welding (Job Sheet 1)
21. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the horizontal position (Job Sheet 2)
22. Conduct root- and face-bend tests and a nick-break test on welded pipe (Job Sheet 3)
23. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up position (Job Sheet 4)
24. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up, 45° inclined position (Job Sheet 5)
25. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down position (Job Sheet 6)
26. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down, 45° inclined position (Job Sheet 7)

Related Academic and Workplace Skills
For *Shielded Metal Arc Pipe Welding, Second Edition*

Task	Skill Group	Sub Skill	Description
Unit 1: Pipe Welding Orientation, Safety, and Equipment			
Solve problems about pipe welding qualification (A.S. 1)	Foundation Skills	Reading	Analyzes written information
	Adaptability Skills	Problem Solving (Critical Thinking)	Recognizes problems and creates effective solutions for them
Unit 2: Print Reading and Layout for Pipe Welding			
Solve trigonometry problems for unknown sides (A.S. 1)	Foundation Skills	Math	Applies computation skills to identify properties of a triangle
Solve trigonometry problems for unknown angles (A.S. 2)	Foundation Skills	Math	Applies computation skills to identify properties of a triangle
Develop a template for a two-piece 90° turn (J.S. 1)	Foundation Skills	Reading	Analyzes a written procedure
	Foundation Skills	Math	Applies knowledge of angles and lines to complete a template
Develop a template for a 90° branch with pipes of equal size (J.S. 2)	Foundation Skills	Reading	Analyzes a written procedure
	Foundation Skills	Math	Applies knowledge of angles and lines to complete a template
Develop a template for a 45° branch connection (J.S. 3)	Foundation Skills	Reading	Analyzes a written procedure
	Foundation Skills	Math	Applies knowledge of angles and lines to complete a template
Unit 3: Pipe Welding Techniques and Applications			
Bevel and prepare pipe for welding (J.S. 1)	Foundation Skills	Reading	Interprets and follows written instructions
	Foundation Skills	Science	Prepares pipe with correct bevel angles
Weld to specifications a V-groove butt joint on 6" schedule 40 pipe in the horizontal position (J.S. 2)	Foundation Skills	Reading	Interprets and follows written instructions
	Foundation Skills	Science	Adapts welding and math skills to complete a pipe weld in a horizontal position

Task	Skill Group	Sub Skill	Description
Conduct root- and face-bend tests and a nick-break test on welded pipe (J.S. 3)	Foundation Skills	Reading	Analyzes technical information to select areas for removal of testing coupons
	Foundation Skills	Science	Adapts welding and measuring skills to prepare proper coupons and conduct tests for pipe weld quality
Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up position (J.S. 4)	Foundation Skills	Reading	Interprets and follows written instructions
	Foundation Skills	Math	Adapts welding and math skills to complete a pipe weld in a vertical up position
Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up, 45° inclined position (J.S. 5)	Foundation Skills	Reading	Interprets and follows written instructions
	Foundation Skills	Math	Adapts welding and math skills to complete a pipe weld in a vertical up test position
Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down position (J.S. 6)	Foundation Skills	Reading	Interprets and follows written instructions
	Foundation Skills	Science	Adapts welding and math skills to complete a pipe weld in the vertical down position
Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down, 45° inclined position (J.S. 7)	Foundation Skills	Reading	Interprets and follows written instructions
	Foundation Skills	Science	Adapts welding and math skills to complete a pipe weld in a vertical down test position

Shielded Metal Arc Pipe Welding, Second Edition

Tools, Equipment, and Materials List

Assorted mild steel pipe nipples
Assortment of welding lens shades
Back-up rings
Ball peen hammer
Bench vise
Center finder
Chipping hammer
Construction paper
Contour marker
Drawing pencil
Face shield
File
Fire extinguisher
Fitter's hammer
Gap wire
Ground clamp
Guided bend tester
Hacksaw
Internal and external line-up clamps
Jack stand with hold-down chain
Level
Oxyacetylene cutting equipment and torch
Oxyacetylene pipe beveling machine
Pedestal grinder and portable grinder
Personal safety clothing
Pliers
Rolling head jack stand
Safety glasses
Scissors
Scotch tape
SMAW electrode and work leads
SMAW electrode holder
SMAW electrodes:
    E XX10
    E XX18
    Others at instructor's option
SMAW welding machine
Soapstone marker
Spring clamp
Steel square
Straightedge
Trammel points
Two-hole pin
Welding helmet
Wing dividers
Wire brush
Work station shielding screens
Wrap-around

Shielded Metal Arc Pipe Welding, Second Edition

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Pipe Welding Orientation, Safety, and Equipment
Unit 1

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss transmission-line and industrial pipe welding, identify AWS welding positions for pipe welding qualification, and solve problems about pipe welding qualification. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to pipe welding orientation, safety, and equipment with their correct definitions.
2. Differentiate between transmission-line pipe welding and industrial pipe welding.
3. Complete statements about characteristics of transmission-line pipe welding.
4. Select true statements about how a cross-country pipe welding crew operates.
5. Select true statements about API classifications for transmission-line pipe.
6. Complete statements about characteristics of industrial pipe welding.
7. Complete statements about classifications for industrial pipe.
8. Complete statements about welding skills required for good pipe welding.
9. Select true statements about organizations that set pipe and pipe welding standards.
10. Identify AWS positions for groove pipe welding.
11. Identify AWS positions for fillet pipe welding.
12. Select true statements about AWS guidelines for G-position qualification.

Objective Sheet

13. Select true statements about AWS guidelines for F-position qualification.
14. Solve problems about guidelines for pipe welding safety.
15. Complete statements about pipe welding situations that require special attention.
16. Select true statements about special precautions for pipe welding hot lines.
17. Complete statements about types of line-up clamps and their characteristics.
18. Select true statements about characteristics of pipe beveling machines.
19. Select true statements about jack stands and their uses.
20. Complete statements about center finders and their uses.
21. Select true statements about types of contour markers.
22. Solve problems about wrap-arounds and their uses.
23. Select true statements about templates and their uses.
24. Complete statements about other pipe welding tools and their uses.
25. Solve problems about pipe welding qualification. (Assignment Sheet 1)

Pipe Welding Orientation, Safety, and Equipment
Unit 1

Suggested Activities

Instructional Plan

Preparation

1. Read unit carefully and plan for instruction.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan for enrichment of exceptional students as well as accommodation of special needs students.
4. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss the assignment sheet. Review criteria for evaluation of this activity.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test.
13. Given written test.
14. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.
15. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Use Objective 8 to point out the difference between general shielded metal arc welding and pipe welding. Impress upon students that the extra hand movement required in pipe welding requires practice. **Learning to learn**, applying procedures to new situations.

2. Talk about opportunities for pipe welders in your state or region, and tie it in with the materials in Objectives 13 and 14 so students will be award of the AWS qualification requirements for groove and filler pipe welding. **Personal management skills**, setting and meeting defined goals and objectives.

3. It would be effective to review safety materials from *Shielded Metal Arc Welding* when you present the safety material in Objective 14. Hot lines and out-of-position welding pose special dangers for a pipe welder, but SMAW safety rules apply to all of pipe welding. **Learning to learn**, adding new safety skills.

4. Demonstrate the use of pipe welding tools as they are presented in Objectives 17 through 24. Stress the time-saving factor built into contour markers and wrap-arounds. **Learning to learn**, adding new application skills.

Resources Used in Developing This Unit

1. Connor, Leonard, P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: The American Welding Society, 1987.

2. O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes*. Miami, FL: American Welding Society, 1991.

3. *Standard Welding Terms and Definitions (ANSI/AWS A3.0-89)*. Miami, FL: American Welding Society, 1989.

4. *Standards Symbols for Welding, Brazing, and Nondestructive Examination (ANSI/AWS A2.4-86)*. Miami, FL: American Welding Society, 1986.

5. *New Lessons in Arc Welding*. Cleveland, OH: The Lincoln Electric Company, 1981.

6. *Standard for Welding Pipelines and Related Facilities, API STD 1104, Fourteenth Edition*. Washington, DC: American Petroleum Institute, 1977.

7. *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS D10.9-80*. Miami, FL: American Welding Society, 1981.

8. Fortney, Clarence and Mike Gregory. *Shielded Metal Arc Pipe Welding*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Activities

Suggested Supplemental Resources

1. "SMAW Pipe Uphill," contains 19 topics, and HOB-4, "SMAW Pipe Downhill," contains 11 topics. both available in ½" VHS and other formats. Available from:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373
   Phone: 513-332-5217

2. MEC-33, "Shielded Metal Arc Pipe Welding, Downhill," and MEC-34, "Shielded Metal Arc Pipe Welding, Uphill," are available as filmstrips with cassettes or other formats. Available from:

   Meridian Education Corporation
   Library Filmstrip Center
   236 East Front Street
   Bloomington, IL 61701
   Phone: 309-827-5455

3. VTR-4, "Pipe Welding," is available in a series of five videotapes and texts. Available from:

   Video Training Resource, Inc.
   7500 West 78th Street
   Edina, NM 55435-2889
   Phone: 800-828-8190 or 612-944-8190

4. Weld #38031 is available in VHS format or ¾" tape. This production details a single weld made on the Alaska pipeline. Available from:

   Alyeska Pipeline Service Co.
   1901 South Bragaw MS 581
   Anchorage, AK 99512
   Phone: 907-265-8871

5. "How to Lay out Pipe and Structural Steel Joints in a Few Minutes with a Contour Marker" is a 31-page, pocket-size guide for using a contour marker to lay out elbows, laterals, Ys, and saddles. the pocket guide is available from Contour Sales, a division of Jackson Products, Inc., and is free to educational instructors. Specify the number of students in your class, and send your request on school stationary to:

   Mr. Robert J. Mills
   Jackson Products, Inc.
   101 South Hanley Road
   St. Louis, MO 63105

Pipe Welding Orientation, Safety, and Equipment
Unit 1

Answers to Assignment Sheet 1

1. b
2. b
3. c
4. c

Pipe Welding Orientation, Safety, and Equipment
Unit 1

Answers to Written Test

1.

a.	6	d.	9	g.	5	j.	7
b.	3	e.	2	h.	1	k.	12
c.	10	f.	11	i.	4	l.	8

2. a. T
   b. I

3. a. Vertical down
   b. One section
   c. A third crew

4. a, b, c

5. b, c

6. a. Smaller, slower
   b. Stricter
   c. Alloy
   d. Bent
   e. Rolled
   f. One welder

7. a. Schedule, wall thickness
   b. Schedule 40
   c. Schedule 80
   d. Schedule 120

8. a. Whatever position it requires
   b. A constant electrode angle
   c. Manual dexterity, hand travel

9. a, b

10. a. 1
    b. 4
    c. 3
    d. 2

11. a. 4
    b. 2
    c. 1
    d. 3

Answers to Written Test

12. a, b, d

13. a, b, d

14. a. 2
    b. 2
    c. 2

15. a. Light to moderate
    b. Oil or gas lines
    c. Driller or tool pusher
    d. Shielding screens

16. a

17. a. Large diameter pipe
    b. Tacked in place prior to

18. c, d

19. b, c

20. a. Dial bubble
    b. Spring loaded
    c. Tank

21. b, c

22. a. 2
    b. 3

23. b

24. a. Adjacent
    b. Penetration

Pipe Welding Orientation, Safety, and Equipment
Unit 1

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

   ______a. American National Standards Institute

   ______b. American Petroleum Institute

   ______c. American Society of Mechanical Engineers

   ______d. American Welding Society

   ______e. Department of Transportation

   ______f. The letter designation for a fillet weld

   ______g. The letter designation for a groove weld

   ______h. A pipeline containing or transporting oil, gas, or any potentially flammable or explosive substance

   ______i. Inside diameter

   ______j. In name only, used in reference to pipe that may vary slightly from stated measurements because of uncontrollable variations in the manufacturing process

   ______k. Outside diameter

   ______l. Numbers used to indicated pipe welding positions

   1. Hot line
   2. DOT
   3. API
   4. I.D.
   5. G
   6. ANSI
   7. Nominal
   8. 1, 2, 4, 5, 6
   9. AWS
   10. ASME
   11. F
   12. O.D.

2. Differentiate between transmission-line pipe welding and industrial pipe welding. Place a "T" beside the definition of transmission-line pipe welding and an "I" beside the definition of industrial pipe welding.

   ______a. The welding of pipes used to carry liquids, gases, and sometimes solids mixed with liquids

   ______b. The welding of pipes used in fixed installations that refine and store oil and gas, manufacture chemicals, or control any materials in a flow-type production facility

Written Test

3. Complete statements about characteristics of transmission-line pipe welding. Circle the material that best completes each of the following statements.

   a. Most transmission-line pipe welding is welded (**horizontal**) (**vertical down**) to give faster welding speed on pipe thicknesses of less than ½" with a ¹⁄₁₆" root gap.

   b. Most transmission-line pipe welding is accomplished in a stovepipe arrangement where all joints are welded to the pipeline (**one section**) (**several sections**) at a time.

   c. Most transmission-line pipe welding used for cross-country work uses one crew to lay the stringer bead, another crew to make the hot pass, and (**a third crew**) (**the same crew**) to lay the filler and cap.

4. Select true statements about how a cross-country pipe welding crew operates. Place an "X" beside each true statement.

   _______a. Two welders working together align the pipe, tack weld as required, and then make the first pass or stringer bead.

   _______b. A hot pass crew then moves in to make the second pass or hot pass after the stringer has been cleaned with a power wire brush or grinder.

   _______c. After the hot pass is cleaned, the filler and cover-pass crew finishes the weld and cleans it for inspection.

5. Select true statements about API classifications for transmission-line pipe. Place an "X" beside each true statement.

   _______a. All transmission-line pipe has a designation of 5L with the "5" indicating the general category and the "L" indicating length.

   _______b. High test line pipe is designated as 5LX with the "X" indicating extra strength.

   _______c. Numbers following the "X" are the first two digits of the minimum yield strength of the pipe expressed in thousands of pounds per square inch.

Written Test

6. Complete statements about characteristics of industrial pipe welding. Circle the material that best completes each of the following statements.

   a. Most industrial pipe welding is welded vertical up with a 3/32″ gap that requires (**smaller**) (**larger**) electrodes than transmission-line welding and (**slower**) (**faster**) welding speeds.

   b. Most industrial pipe welding is done under (**stricter**) (**different**) codes than required for transmission-line welding because the high pressures to which the pipes are frequently subjected pose a greater danger to people and property.

   c. Industrial pipe welding uses a greater variety of (**alloy**) (**carbon**) steels than are normally used in transmission-line welding.

   d. Industrial pipe welding sometimes requires a welder to work in confined areas so cramped that a mirror has to be used to get a good view of the work and a (**bent**) (**shortened**) electrode has to be used to reach the work.

   e. Industrial pipe welding is often done in a shop where the pipe can be (**rolled**) (**lifted**) to avoid out-of-position welding.

   f. Industrial pipe welding joints are usually completed stringer to cap by (**only two welders**) (**one welder**), not team welders as in cross-country work.

7. Complete the statements about classifications for industrial pipe. Circle the material that best completes each of the following statements.

   a. Industrial pipe is classified according to a (**pipe**) (**schedule**) number related to the (**diameter**) (**wall thickness**) diameter of the pipe in inches.

   b. Standard weight industrial pipe is known as (**Schedule 40**) (**Schedule 80**).

   c. Extra strong industrial pipe is known as (**EX 40**) (**Schedule 80**).

   d. Extra heavy wall industrial pipe is known as (**Schedule 120**) (**EXX 40**).

8. Complete statements about welding skills required for good pipe welding. Circle the material that best completes each of the following statements.

   a. A pipe welder has to weld in (**overhead and vertical positions**) (**whatever position it requires**) to reach the joint.

   b. A pipe welder has to maintain (**a steady hand**) (**a constant electrode angle**) as the bead is moved around the circumference of the pipe.

   c. Pipe welding demands more (**patience**) (**manual dexterity**) than plate welding because there must be a greater amount of (**adjustment**) (**hand travel**) compared to the travel at the end of the arc.

Written Test

9. Select true statements about organizations that set pipe and pipe welding standards. Place an "X" beside each true statement.

Note: For a statement to be true, all parts of the statement must be true.

______a. The API sets standards for pipe and welding and fitting pipe covered by:

(1) standard 5L for line pipe;

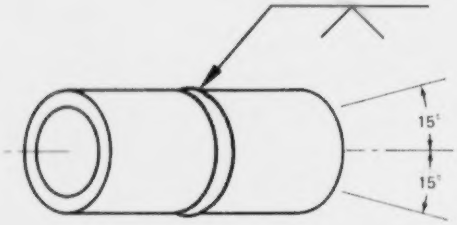
(2) other standards covering qualification of welding procedures, joint design and preparation, and inspection and testing as covered in Standard 1104.

______b. The ASME sets standards and safety requirements for pipe and pipe welding as related to the design and construction of boilers and other high-pressure vessels are covered in Section IX.

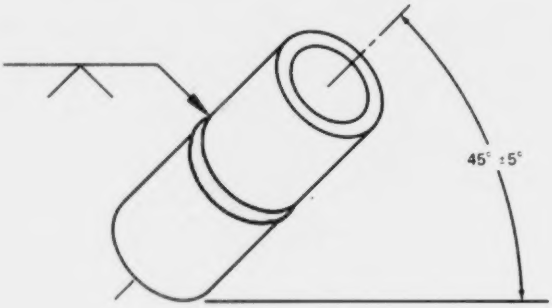
______c. The AWS sets specifications for industrial pipe only.

10. Identify AWS position for groove pipe welding. Place the number of the position in the blank below the appropriate illustration.

1. 1G
2. 2G
3. 5G
4. 6G

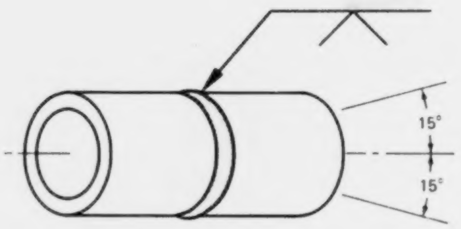


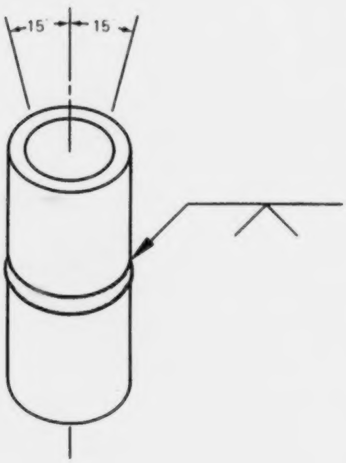
a. _____



b. _____

Written Test



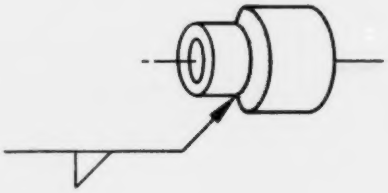


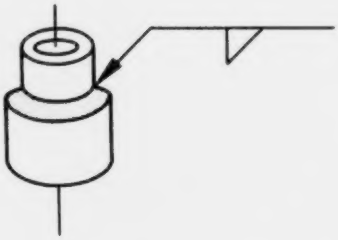
c. ______

d. ______

11. Identify AWS positions for fillet pipe welding. Place the number of the position in the blank below the appropriate illustration.

    1. 1F
    2. 2F
    3. 4F
    4. 5F

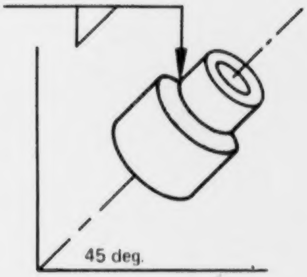




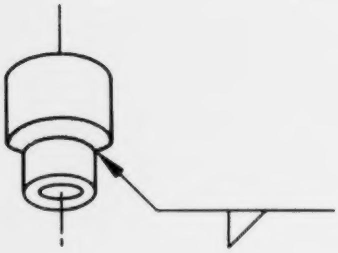
a. ______

b. ______

Written Test



c. ______



d. ______

12. Select true statements about AWS guidelines for G-position qualification. Place an "X" beside each true statements.

______a. Qualification in the 1G position qualifies for welding only in the 1G position.

______b. Qualification in the 2G position qualifies for welding in the 1G and 2G positions only.

______c. Qualification in the 5G position qualifies for welding in the 1G, 2G, and 5G positions.

______d. Qualification in the 6G position qualifies for welding in any position because it includes elements of all positions.

13. Select true statements about AWS guidelines for F-position qualification. Place an "X" beside each true statement.

______a. Qualification in the 1F position qualifies for fillet welding only in the 1F position

______b. Qualification in the 2F position qualifies for fillet welding in the 1F and 2F positions only.

______c. Qualification in the 4F position qualifies for fillet welding in the 1F, and 4F positions only.

______d. Qualification in the 5F position qualifies for fillet welding in any position because it includes elements of all positions.

Written Test

14. Solve problems about guidelines for pipe welding safety. Circle the number of the best solution to each of the following problems.

    a. A welder is getting ready to work in a confined space. You notice the welder is wearing a heavy shirt. It there a problem? If so, how should it be solved?

        (1) There is no problem. A heavy shirt is just right for the job.

        (2) There is a problem. The welder should definitely wear protective leather sleeves.

        (3) There is a problem. The welder should wear a welding apron.

    b. A fellow worker is transporting a pipe beveling machine carelessly in one hand. Is there a problem? If so, how should it be solved?

        (1) There is a problem. Have someone help carry the beveling machine.

        (2) There is a problem. Have the fellow worker secure the beveling machine with both hands because the machines are easily damaged if dropped.

        (3) There is no problem so long as the fellow worker has a good hold on the machine.

    c. On a cross-country job, it begins to rain. The welders want to know whether or not to continue. Is there a problem? If so, how should it be solved.

        (1) There is no problem. Pipe welding can be done in the rain.

        (2) There is a problem. Do not pipe weld in rain. Stop until the rain quits.

        (3) There is a problem. Set up shields to protect the welders from the rain.

15. Complete statements about pipe welding situations that require special attention. Circle the material that best completes each of the following statements.

    a. When field welding pipe in a grassy area, be especially careful of fire, and doubly careful in the presence of (**light to moderate**) (**heavy**) winds.

    b. When pipe welding in situations where (**storage tanks**) (**oil or gas lines**) are present, check with a supervisor to make sure the area is safe to weld in.

    c. Before pipe welding or cutting on an oil or gas drilling rig, check with the (**driller or tool pusher**) (**an engineer**) to make sure the area is safe to weld in.

    d. Use (**care**) (**shielding screens**) in all instances where sparks from cutting or arc welding could pose a danger to nearby workers or equipment.

Written Test

16. Select true statements about special precautions for pipe welding hot lines. Place an "X" beside each true statement.

______a. Never cut into or weld on a line without knowing for certain that it is safe.

______b. Never cut into or weld on a hot line without first placing shielding screens around the line.

17. Complete statements about types of line-up clamps and their characteristics. Circle the material that best completes each of the following statements.

a. Internal line-up clamps fit inside pipes to align connecting sections of pipe or pie-to-flange fit-ups, and are sometimes specified for use with (**cross-country pipe**) (**large diameter pipe**).

b. External line-up clamps fit outside pipes to align connecting sections of pipe or pipe-to-flange fit-ups so pipes can be (**held in place for**) (**tacked in place prior to**) welding.

18. Select true statements about characteristics of pipe beveling machines. Place an "X" beside each true statement.

______a. Most pipe beveling machines cut bevel angles as required in almost all positions and on pipe diameters ranging from 2" to 24".

______b. Pipe beveling machines are always oxyfuel rigs.

______c. Portable pipe beveling machines are popular because they can be used both in a shop and in the field.

______d. Stationary pipe beveling machines are popular in fabrication shops and vocational training programs because they are easy to operate and eliminate wasted pipe.

19. Select true statements about jack stands and their uses. Place an "X" beside each true statement.

______a. Jack stands are used primarily to align pipe to be welded and to support it only while it is being tacked.

______b. Jack stands cradle pipe in a V-shaped channel that can be vertically adjusted to raise or lower a pipe section so it can be aligned with an adjoining section.

______c. Jack stands used in pairs or several jack stands used on long lengths of adjoining pipe have to be manually positioned for side to side alignment.

______d. Some jack stands come equipped with hold-down chains or devices that fit over the pipe to secure it to the stand for situations that require fit-ups with long sections.

Written Test

20. Complete statements about center finders and their uses. Circle the material that best completes each of the following statements.

    a. Center finders are used to find the center of a pipe by using an adjustable protractor and a (**T-square**) (**dial bubble**).

    b. Center finders may have centering pins that are (**automatic**) (**spring loaded**) and manually activated or centering pins that have to be struck with a hammer to mark the center of a pipe.

    c. Center finders can also be used for establishing and marking angles for off-center fit-ups and for both pipe and (**plate**) (**tank**) layout.

21. Select true statements about types of contour markers. Place an "X" beside each true statement.

    ______a. Standard contour markers are used for finding and marking contours and angles on pipe diameters from ½″ to 72″.

    ______b. Jumbo contour markers are used for finding and marking contours and angles on pipe diameters from 18″ to 48″.

    ______c. Contour markers are extremely versatile tools which can be used to lay out Tees, Y's, and laterals, and they speed up layout because mathematical calculations are built-in.

22. Solve problems about wrap-arounds and their uses. Circle the number of the material that best solves each of the following problems.

    a. You notice a fellow worker trying to use a wrap-around to mark an angle on the pipe. You should:

       (1) Remind your friend that angles are difficult to find with a wrap-around.

       (2) Remind your friend that wrap-arounds are intended to help mark a pipe so that the end can be squared.

       (3) Give your friend a hand because wrap-arounds used at angles have a tendency to slip.

    b. You are working with a wrap-around that goes one and a half times around the pipe your are measuring. You should:

       (1) Be extremely careful with your measurement.

       (2) Mark the pipe on top, and then on bottom.

       (3) Get a wrap-around at least seven times the diameter of the pipe and do the job right.

Written Test

23. Select true statements about templates and their uses. Place an "X" beside each true statement.

______a. Templates are pre-cut patterns made only for large diameters of pipe as guides for cutting tees, elbows, and almost all types of pipe fittings.

______b. Manufactured templates are available in sets for specific diameters of pipes, but many templates are laid out and cut in a shop or at a job site to eliminate the need for repeated figuring of pipe joints that are used often in one application.

24. Complete statements about other pipe welding tools and their uses. Circle the material that best completes each of the following statements.

a. Two-hole pins have a level-type bubble which is used to level the top or bottom two holes of a flange by inserting the two pins in (**opposite**) (**adjacent**) bolt holes and moving the flange until it is level.

b. Back-up rings are used inside connecting butt joints to help align them, provide proper gap, and control (**variation**) (**penetration**) in the weld zone.

***Permission to duplicate this test is granted.**

Pipe Welding Orientation, Safety, and Equipment
Unit 1

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Solve Problems About Pipe Welding Qualifications Rating _____

Comments: ____

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ____

____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

***Permission to duplicate this form is granted.**

Pipe Welding Orientation, Safety, and Equipment
Unit 1

Information Sheet

1. **Terms and definitions**
    a. **ANSI** — American National Standards Institute
    b. **API** — American Petroleum Institute
    c. **ASME** — American Society of Mechanical Engineers
    d. **AWS** — American Welding Society
    e. **DOT** — Department of Transportation
    f. **F** — The letter designation for a fillet weld
    g. **G** — The letter designation for a groove weld
    h. **Hot line** — A pipeline containing or transporting oil, gas, or any potentially flammable or explosive substance
    i. **I.D.** — Inside diameter
    j. **Nominal** — In name only, used in reference to pipe that may vary slightly from stated measurements because of uncontrollable variations in the manufacturing process
    k. **O.D.** — Outside diameter
    l. **1, 2, 4, 5, 6** — Numbers used to indicated pipe welding positions
2. **Types of pipe welding and their characteristics**
    a. **Transmission-line pipe welding** — The welding of pipes used to carry liquids, gases, and sometimes solids mixed with liquids
    b. **Industrial pipe welding** — The welding of pipes used in fixed installations that refine and store oil and gas, manufacture chemicals, or control any materials in a flow-type production facility
3. **Characteristics of transmission-line pipe welding**
    a. Most transmission-line pipe welding is welded vertical down to give faster welding speed on pipe thicknesses of less than $\frac{1}{2}$" with a $\frac{1}{16}$" root gap.
    b. Most transmission-line pipe welding is accomplished in a stovepipe arrangement where all joints are welded to the pipeline one section at a time.
    c. Most transmission-line pipe welding used for cross-country work uses one crew to lay the stringer bead, another crew to make the hot pass, and a third crew to lay the filler and cap.

Information Sheet

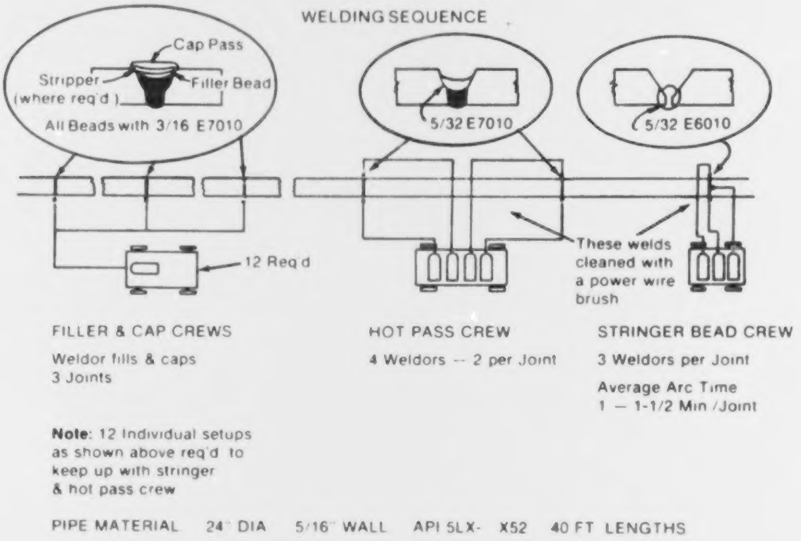
4. How a cross-country pipe welding crew operates

a. Two welders working together align the pipe, tack weld as required, and then make the first pass or stringer bead.

Note: When internal line-up clamps or "grasshoppers" are used tack welds are not required, but when external clamps are used, tack welds are required.

b. A hot pass crew then moves in to make the second pass or hot pass after the stringer has been cleaned with a power wire brush or grinder.

c. After the hot pass is cleaned, the filler and cover-pass crew finishes the weld and cleans it for inspection.


WELDING SEQUENCE
Cap Pass
Stripper (where req'd)
Filler Bead
All Beads with 3/16 E7010
5/32 E7010
5/32 E6010
12 Req'd
These welds cleaned with a power wire brush
FILLER & CAP CREWS
Weldor fills & caps 3 Joints
HOT PASS CREW
4 Weldors -- 2 per Joint
STRINGER BEAD CREW
3 Weldors per Joint
Average Arc Time 1 — 1-1/2 Min /Joint
Note: 12 Individual setups as shown above req'd to keep up with stringer & hot pass crew
PIPE MATERIAL 24" DIA 5/16" WALL API 5LX- X52 40 FT LENGTHS

Courtesy Lincoln Electric Company

5. API classifications for transmission-line pipe

a. All transmission-line pipe has a designation of 5L with the "5" indicating the general category and the "L" indicating line pipe.

b. High test line pipe is designated as 5LX with the "X" indicating extra strength.

c. Numbers following the "X" are the first two digits of the minimum yield strength of the pipe expressed in thousands of pounds per square inch.

Information Sheet

Grade	Yield Min., psi	Tensile Min., psi
X42	42,000	60,000
X46	46,000	63,000
X52	52,000	66,000
X56	56,000	71,000†
X60	60,000	75,000†
X65	65,000	77,000†
X70	70,000	

† Pipe 20" OD and larger with wall thickness 0.375" and less requirement is 3 — 4,000 psi higher.

Courtesy Lincoln Electric Company

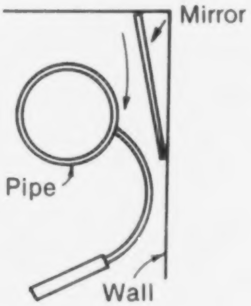
6. Characteristics of industrial pipe welding

a. Most industrial pipe welding is welded vertical up with a $\frac{3}{32}$" gap that requires smaller electrodes than transmission-line welding and slower welding speeds.

b. Most industrial pipe welding is done under stricter codes than required for transmission-line welding because the high pressures to which the pipes are frequently subjected pose a greater danger to people and property.

c. Industrial pipe welding uses a greater variety of alloy steels than are normally used in transmission-line welding.

d. Industrial pipe welding sometimes requires a welder to work in confined areas so cramped that a mirror has to be used to get a good view of the work and a bent electrode has to be used to reach the work.



e. Industrial pipe welding is often done in a shop where the pipe can be rolled to avoid out-of-position welding.

f. Industrial pipe welding joints are usually completed stringer to cap by one welder, not team welders as in cross-country work.

Information Sheet

7. Classifications for industrial pipe

a. Industrial pipe is classified according to a schedule number related to the wall thickness of the pipe in inches.

Note: When checking pipe size, check ID for pipe up to and including 12″ in diameter, and check OD for pipe 12″ and over in diameter.

b. Standard weight industrial pipe is known as Schedule 40.

TABLE I — DIMENSIONS OF SCHEDULE 40 (Standard Weight)

Steel and Wrought Iron Pipe

Nominal Diameter, Inches	Actual Outside Diameter (In.)	Wall Thickness, Inches	Weight Per foot, Pounds
3	3.500	.216	7.58
3½	4.000	.226	9.11
4	4.500	.237	10.80
5	5.563	.258	14.70
6	6.625	.280	19.00
8	8.625	.322	28.60
10	10.750	.365	40.50
12	12.750	.406	53.60
14	14.000	.437	63.30
16	16.000	.500	82.80
18	18.000	.562	105.00
20	20.000	.593	123.00
24	24.000	.687	171.00

Courtesy Lincoln Electric Company

Information Sheet

c. Extra strong industrial pipe is known as Schedule 80.

TABLE II — DIMENSIONS OF SCHEDULE 80 (Extra Strong)

Steel and Wrought Iron Pipe			
Nominal Diameter, Inches	**Actual Outside Diameter (In.)**	**Wall Thickness, Inches**	**Weight Per foot, Pounds**
3	3.500	.300	10.252
3½	4.000	.318	12.505
4	4.500	.337	14.983
5	5.563	.375	20.778
6	6.625	.432	28.573
8	8.625	.500	43.388
10	10.750	.593	64.400
12	12.750	.687	88.600
14	14.000	.750	107.00
16	16.000	.843	137.00
18	18.000	.937	171.00
20	20.000	1.031	209.00
24	24.000	1.218	297.00

Courtesy Lincoln Electric Company

d. Extra heavy wall industrial pipe is known as Schedule 120.

TABLE III — DIMENSIONS OF SCHEDULE 120

Steel and Wrought Iron Pipe			
Nominal Diameter, Inches	**Actual Outside Diameter (In.)**	**Wall Thickness, Inches**	**Weight Per foot, Pounds**
4	4.500	.437	19.0
5	5.563	.500	27.1
6	6.625	.562	36.4
8	8.625	.718	60.7
10	10.750	.843	89.2
12	12.750	1.000	126.0
14	14.00	1.062	147.0
16	16.00	1.218	193.0
18	18.00	1.343	239.0
20	20.00	1.500	297.0
24	24.00	1.750	416.0

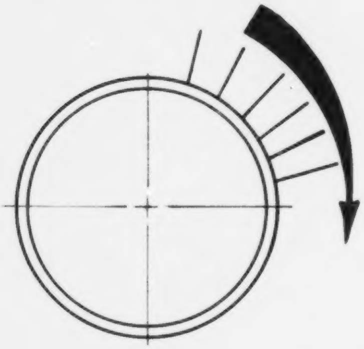
Courtesy Lincoln Electric Company

8. **Welding skills required for good pipe welding**

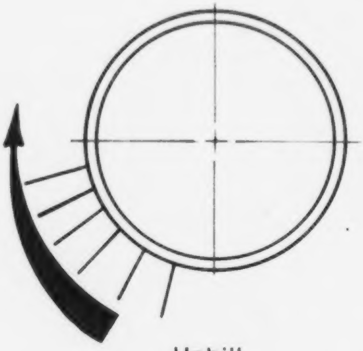
   a. A pipe welder has to weld in whatever position it requires to reach the joint.

   b. A pipe welder has to maintain a constant electrode angle as the bead is moved around the circumference of the pipe.

   c. Pipe welding demands more manual dexterity than plate welding because there must be a greater amount of hand travel compared to the travel at the end of the arc.



Downhill
(Cross-Country)



Uphill
(Industrial)

9. **Organizations that set pipe and pipe welding standards**

   a. The API (American Petroleum Institute) sets standards for pipe and welding and fitting pipe covered by:

      (1) standard 5L for line pipe;

      (2) other standards covering qualification of welding procedures, joint design and preparation, and inspection and testing as covered in Standard 1104.

   b. The ASME (American Society of Mechanical Engineers) sets standards and safety requirements for pipe and pipe welding as related to the design and construction of boilers and other high-pressure vessels are covered in Section IX.

   c. The AWS (American Welding Society) sets specifications for qualification of welding procedures and welders for piping and tubing as covered in AWS D10.9.

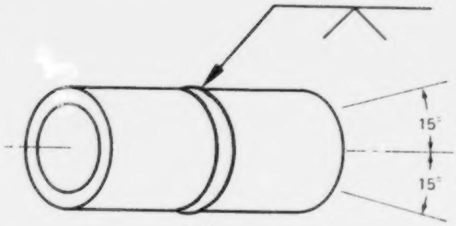
Information Sheet

10. AWS positions for groove pipe welding

a. Position 1G:

(1) Pipe horizontal rolled, weld flat (± 15°)

(2) Rotate pipe and deposit weld at or near the top

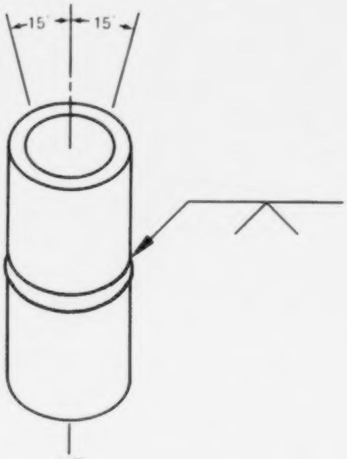


1G

b. Position 2G:

(1) Pipe vertical, weld horizontal (± 15°)

(2) Pipe shall not be rotated during welding

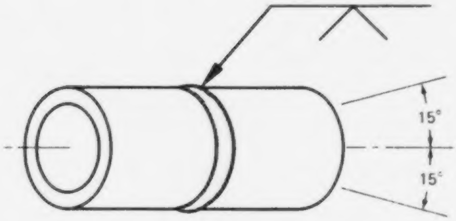


2G

c. Position 5G

(1) Pipe horizontal fixed (± 15°), weld flat, vertical overhead

(2) Pipe shall not be rotated during welding

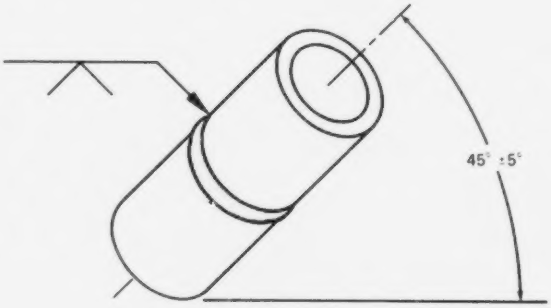


5G

d. Position 6G:

(1) Pipe inclined fixed (± 5°), weld vertical

(2) Pipe shall not be rotated during welding



6G

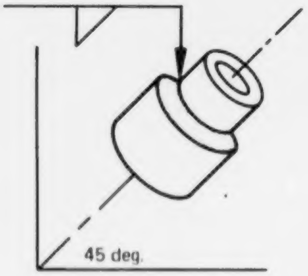
Information Sheet

11. AWS positions for fillet pipe welding

a. Position 1F:

(1) Pipe rotated at 45°

(2) Fillet weld flat at or near the top

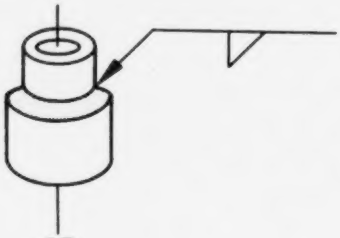


1F

b. Position 2F:

(1) Pipe vertical fixed (± 15°)

(2) Fillet weld horizontal

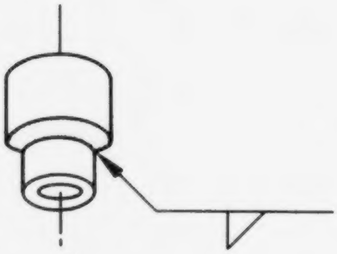


2F

c. Position 4F:

(1) Pipe vertical fixed (± 15°)

(2) Fillet weld overhead

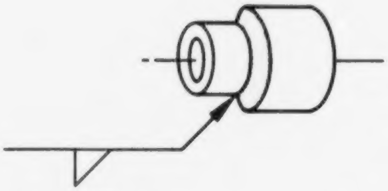


4F

d. Position 5F:

(1) Pipe horizontal fixed

(2) Fillet weld horizontal, vertical, and overhead



5F

Information Sheet

12. AWS guidelines for G-position qualification

a. Qualification in the 1G position qualifies for welding only in the 1G position.

b. Qualification in the 2G position qualifies for welding in the 1G and 2G positions only.

c. Qualification in the 5G position qualifies for welding in the 1G and 5G positions only.

d. Qualification in both the 2G and 5G positions qualifies for welding in any position.

e. Qualification in the 6G position qualifies for welding in any position because it includes elements of all positions.

13. AWS guidelines for F-position qualification

a. Qualification in the 1F position qualifies for fillet welding only in the 1F position.

b. Qualification in the 2F position qualifies for fillet welding in the 1F and 2F positions only.

c. Qualification in the 4F position qualifies for fillet welding in the 1F, 2F, and 4F positions only.

d. Qualification in the 5F position qualifies for fillet welding in any position because it includes elements of all positions.

e. Qualification in any of the fixed G positions qualifies for the fillet welding of any fillet weld in pipe.

14. Guidelines for pipe welding safety

a. Wear proper protective clothing for both oxyacetylene cutting and arc welding.

b. Wear protective leather sleeves to protect from sparks in confined quarters and out-of-position welding.

c. Unroll and roll up lead cables with care.

d. Handle beveling machines with care because they are easy to damage if dropped.

e. Handle free ends of pipe being beveled with tongs or pliers to keep them from dropping on your feet.

Information Sheet

f. Keep flammable materials away from the welding area and make sure there is proper ventilation.

g. Keep a correct type fire extinguisher nearby when pipe welding in a shop and have one at a convenient location when welding in the field.

h. Use windshields when they are practical, but do not pipe weld in rain or in high winds or blowing sand.

15. Pipe welding situations that require special attention

a. When field welding pipe in a grassy area, be especially careful of fire, and doubly careful in the presence of light to moderate winds.

b. When pipe welding in situations where oil or gas lines are present, check with a supervisor to make sure the area is safe to weld in.

c. Before pipe welding or cutting on an oil or gas drilling rig, check with the driller or tool pusher to make sure the area is safe to weld in.

d. Use shielding screens in all instances where sparks from cutting or arc welding could pose a danger to nearby workers or equipment.

16. Special precautions for pipe welding hot lines

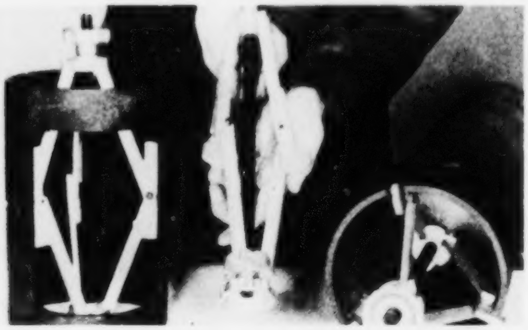
a. **NEVER** cut into or weld on a line without knowing for certain that it is safe.

b. **NEVER** cut into or weld on a hot line without going through the proper procedure for obtaining a "hot work" or entry permit from a supervisor authorized to grant such permission.

Information Sheet

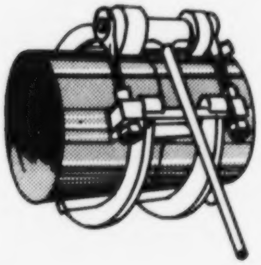
17. Types of line-up clamps and their characteristics

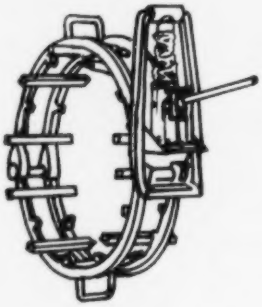
a. Internal line-up clamps fit inside pipes to align connecting sections of pipe or pipe-to-flange fit-ups, and are sometimes specified for use with large diameter pipe.



Courtesy Contour Sales, Jackson Industries, Inc.

b. External line-up clamps fit outside pipes to align connecting sections of pipe or pipe-to-flange fit-ups so pipes can be tacked in place prior to welding.



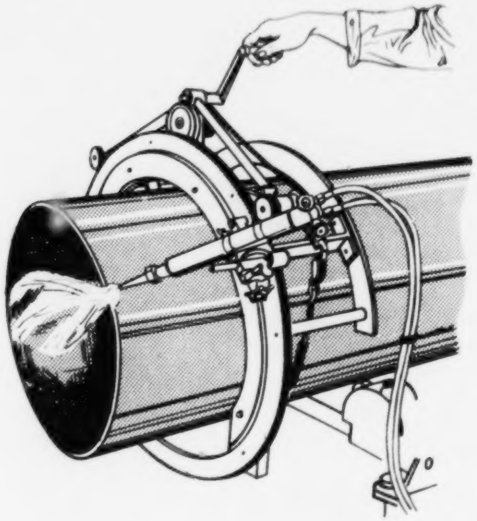


18. Characteristics of pipe beveling machines

a. Most pipe beveling machines cut bevel angles as required in almost all positions and on pipe diameters ranging from 2″ to 74″.

b. Pipe beveling machines are often oxyfuel rigs, but may be electric or pneumatic.

c. Portable pipe beveling machines are popular because they can be used both in a shop and in the field.



d. Stationary pipe beveling machines are popular in fabrication shops and vocational training programs because they are easy to operate and eliminate wasted pipe.

19. Jack stands and their uses

a. Jack stands are used primarily to align pipe to be welded and to support it while it is being welded or tacked.

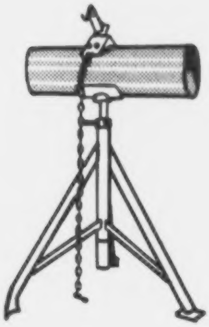
b. Jack stands cradle pipe in a V-shaped channel that can be vertically adjusted to raise or lower a pipe section so it can be aligned with an adjoining section.

BEST COPY AVAILABLE

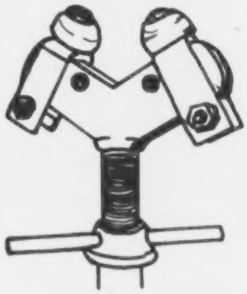
Information Sheet

c. Jack stands used in pairs or several jack stands used on long lengths of adjoining pipe have to be manually positioned for side to side alignment.

d. Some jack stands come equipped with hold-down chains or devices that fit over the pipe to secure it to the stand for situations that require fit-ups with close tolerances.



Jack With Hold-Down Chain



Rolling Jack-Head

20. Center finders and their uses

a. Center finders are used to find the center of a pipe by using an adjustable protractor and a dial bubble.

b. Center finders may have centering pins that are spring loaded and manually activated or centering pins that have to be struck with a hammer to mark the center of a pipe.

Information Sheet

c. Center finders can also be used for establishing and marking angles for off-center fit-ups and for both pipe and tank layout.

Courtesy Contour Sales, Jackson Industries, Inc.

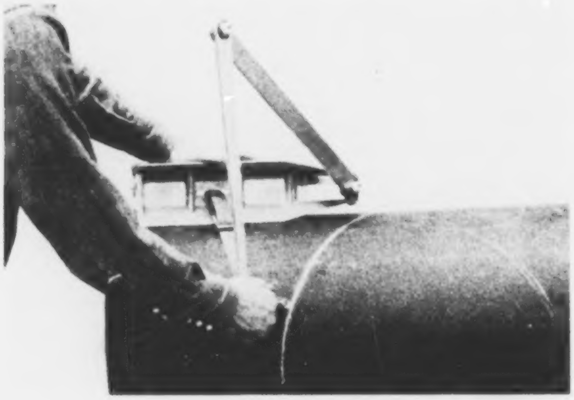
21. Types of contour markers

a. Standard contour markers are used for finding and marking contours and angles on pipe diameters from 1½" to 18".

Courtesy Contour Sales, Jackson Industries, Inc.

Information Sheet

b. Jumbo contour markers are used for finding and marking angles on pipe diameters from 18″ to 48″.



Courtesy Contour Sales, Jackson Industries, Inc.

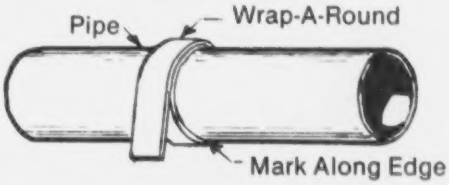
c. Contour markers are extremely versatile tools which can be used to lay out Tees, Y's, and laterals, and they speed up layout work because mathematical calculations are built-in.

22. Wrap-arounds and their uses

a. Wrap-arounds are usually made of durable gasket materials with edges that are perfectly straight and parallel.

b. Wrap-arounds are used primarily for marking a straight line around the end of a pipe so that the end may be squared.

c. A wrap-around should be at least seven times as long as the diameter of the pipe being marked, and should be wrapped around the pipe two times to make sure the line around the pipe is straight.



Courtesy Contour Sales Corporation

d. A wrap-around may be used as a straightedge or with a square and a level to lay out elbows, tees, and other fittings, but these activities require advanced layout skills.

Note: See Student Supplement 1

Information Sheet

23. Templates and their uses

a. Templates are pre-cut patterns made for specific diameters of pipe as guides for cutting tees, elbows, and almost all types of pipe fittings.

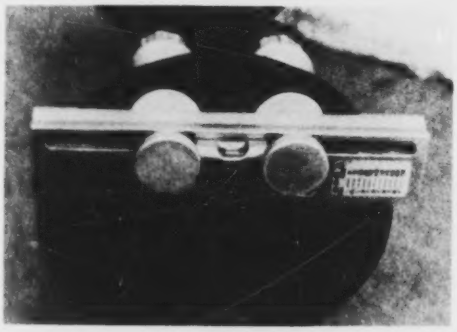
b. Manufactured templates are available in sets for specific diameters of pipes, but many templates are laid out and cut in a shop or at a job site to eliminate the need for repeated figuring of pipe joints that are used often in one application.

Note: See Student Supplement 1

24. Other pipe welding tools and their uses

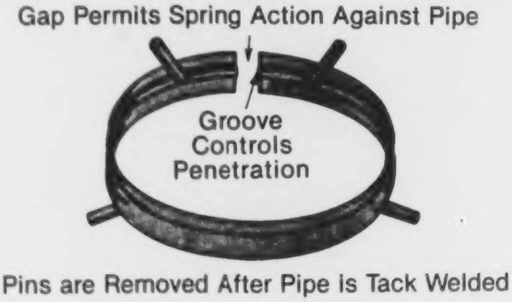
a. Two-hole pins have a level-type bubble which is used to level the top or bottom two holes of a flange by inserting the two pins in adjacent bolt holes and moving the flange until it is level.

Note: These devices assure that the connecting flanges will be in line and on center.



Courtesy Contour Sales, Jackson Industries, Inc.

b. Back-up rings are used inside connecting butt joints to help align them, provide proper gap, and control penetration in the weld zone.

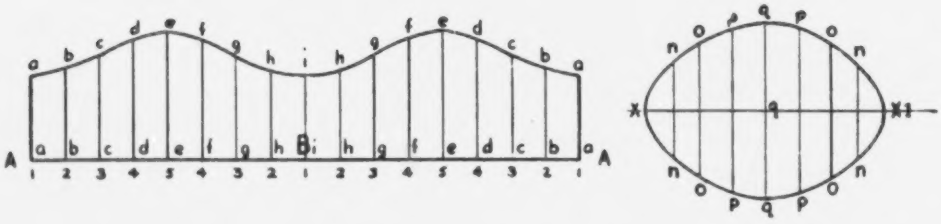

Gap Permits Spring Action Against Pipe
Groove Controls Penetration
Pins are Removed After Pipe is Tack Welded

Pipe Welding Orientation, Safety, and Equipment
Unit 1

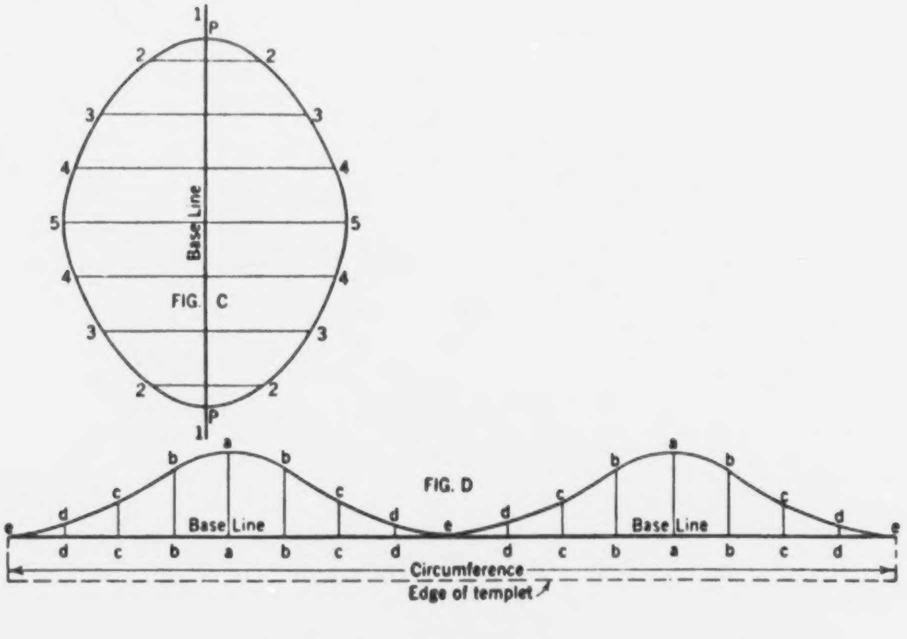
Student Supplement 1—Wrap-arounds and Templates

Templates and wrap-arounds re used frequently to measure and mark pipe so that it can be cut precisely to save time and avoid waste. Study the templates and the wrap-around included with this supplement and you will be able to visualize how effective both can be.

Pipe Welding Templates


a b c d e f g h i h g f e d c b a
A
B
1 2 3 4 5 4 3 2 1 2 3 4 5 4 3 2 1
n o p q p o n
X
q
X1

90° Branch With Branch Smaller Than Header

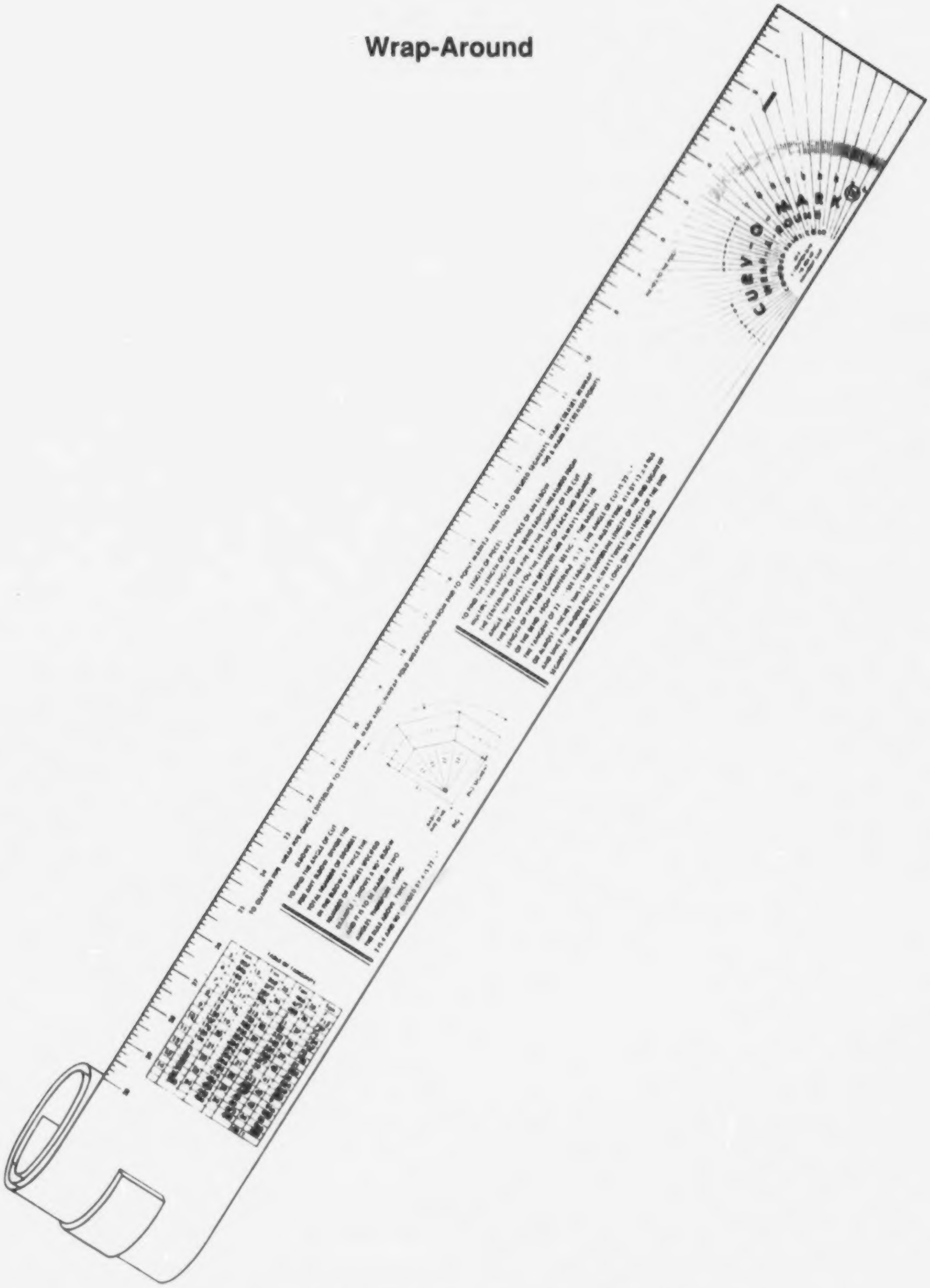

1 P
2 2
3 3
4 4
5 5
Base Line
FIG. C
P 1
a b c d e
FIG. D
Base Line
d c b a b c d
Circumference
Edge of templet

90° Branch With Branch and Header of Equal Diameter

Courtesy Union Carbide Corporation, Linde Division

Student Supplement 1

Wrap-Around


CURV-O-MARK
WRAP-AROUND

Courtesy Contour Sales, Jackson Industries, Inc.

Pipe Welding Orientation, Safety, and Equipment
Unit 1

Assignment Sheet 1—Solve Problems About Pipe Welding Qualification

Name ______________________________ Overall Rating __________

Evaluation criterion	Rating
Number of problems properly solved	______

Directions Circle the item that best solves each of the following problems.

1. A welder will be working on a job that requires groove welding in both the flat and horizontal positions. The welder is qualified in the 5G position. Should the welder be hired for the job?

   a. Yes. The 5G position qualification means the welder can work in any position.

   b. No. The 5G position qualification means the welder can work in the 1G and 5G positions only.

   c. Yes. Qualification in the 5G position means the welder can learn any position requirements on the job.

2. A beginning welder working for 1G qualification complains that the pipe should be repositioned because it is difficult to move the electrode in under the pipe. To solve the problem:

   a. Move the pipe so that it will be easier to reach.

   b. Check the qualification procedure because the 1G qualification requires that the pipe be rotated. There is not need to move around the pipe.

   c. Give the welder a shorter electrode so it will be easier to stay close to the work.

Assignment Sheet 1

3. Hiring is taking place for a crew that will be working on a fillet pipe welding job. Since the welding will require skills in all fillet positions, each welder should be qualified in:

   a. The 4F position because that covers both the 1F and 2F positions.

   b. The 2F position because that covers the 1F position too.

   c. The 5F position because it includes elements of all positions.

4. Hiring is taking place for a crew that will be working on both fillet and groove pipe welding. Welding will be done in several positions on both fillet and groove welds. The best crew that could be hired would be:

   a. Welders that are qualified in both the 5G and 5F positions.

   b. Welders that are qualified in both the 4G and 4F positions.

   c. Welders that are qualified in the 6G position.

Print Reading and Layout for Pipe Welding
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to use trigonometric functions to find unknown sides and angles, and prepare templates for a 90° turn, a 90° branch, and a 45° branch. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to print reading and layout for pipe welding with their correct definitions.
2. Identify methods for presenting pipe on prints.
3. Complete statements about pipe symbols and their uses.
4. Match common pipe symbols with their meanings.
5. Identify methods for dimensioning prints for pipe welding.
6. Complete statements about symbols for common pipe fittings.
7. Match special welded fittings with their uses.
8. Select true statements about advantages of isometric drawings for pipe welding prints.
9. Complete statements about functions of a right triangle.
10. Select true statements about steps in solving trigonometric problems.
11. Arrange in order the steps in laying out angles on 90° long radius elbows.
12. Solve a problems using the 12-inch rule for finding angles with a steel square.

Objective Sheet

13. Complete statements about standard references for commercial pipe identification.

14. Match standard weld fittings with their shapes.

15. Solve trigonometry problems for unknown sides. (Assignment Sheet 1)

16. Solve trigonometry problems for unknown angles. (Assignment Sheet 2)

17. Develop a template for a two-piece 90° turn. (Job Sheet 1)

18. Develop a template for a 90° branch with pipes of equal size. (Job Sheet 2)

19. Develop a template for a 45° branch connection. (Job Sheet 3)

Print Reading and Layout for Pipe Welding
Unit 2

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan for enrichment of exceptional students as well as accommodation of special needs students.
4. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss the assignment and job sheets. Review criteria for evaluation of these activities.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test. Add or modify test items as needed.
13. Give written test.
14. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.
15. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Review Unit 6, "Welding Print Reading" and Unit 7, "Basic Welding Joints and Symbols" from MAVCC's *Fundamentals of Welding*. Use those materials to refresh student skills in the basics of print reading and how those basics also apply to pipe prints. Skill area: **learning to learn**.

2. Invite a drafting instructor to class to talk to students about isometric drawings and why they are particularly effective for pipe welding prints. Ask the instructor to bring available pipe prints for students to examine. Skill area: **learning to learn**.

3. Try to locate an industry or firm in your area that does pipe welding. Ask a pipe welder to demonstrate layout methods that are used locally. Try to find a pipe welder who can demonstrate how to use a steel square for finding angles on pipe turns. This will be especially effective with Objective 12. Skill area: **learning to learn**.

4. Have several templates available as you demonstrate the job sheets. Transfer the templates to paper and make paper mock-ups of a T or a branch so students will have a better visual perspective of what a template accomplishes. Skill area: **math**.

Resources Used in Developing This Unit

1. Fortney, Clarence and Mike Gregory. *Shielded Metal Arc Pipe Welding*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

2. Davis, Ronald and Donald White. *Pipe Drafting*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1983.

3. Morse, Otto and Leonard Jones. *Basic Sheet Metal Layout and Fabrication*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1983.

4. Dearman, Tim. *The Dearman System*. Pearland, TX: Dearman International, Inc., 1979.

5. Bennett, A. E. and Louis J. Siy. *Blueprint Reading for Welders, 4th Ed.* Albany, NY: Delmar Publishers, Inc., 1988.

6. Althouse, Andrew D., et. al. *Modern Welding*. South Holland, IL: The Goodheart-Willcox Company, Inc., 1992.

Suggested Activities

Suggested Supplemental Resources

1. "SMAW Pipe Uphill," contains 19 topics, and HOB-4, "SMAW Pipe Downhill," contains 11 topics. both available in ½" VHS and other formats. Available from:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373
   Phone: 513-332-5217

2. MEC-33, "Shielded Metal Arc Pipe Welding, Downhill," and MEC-34, "Shielded Metal Arc Pipe Welding, Uphill," are available as filmstrips with cassettes or other formats. Available from:

   Meridian Education Corporation
   Library Filmstrip Center
   236 East Front Street
   Bloomington, IL 61701
   Phone: 309-827-5455

3. VTR-4, "Pipe Welding," is available in a series of five videotapes and texts. Available from:

   Video Training Resource, Inc.
   7500 West 78th Street
   Edina, NM 55435-2889
   Phone: 800-828-8190 or 612-944-8190

4. Weld #38031 is available in VHS format or ¾" tape. This production details a single weld made on the Alaska pipeline. Available from:

   Alyeska Pipeline Service Co.
   1901 South Bragaw MS 581
   Anchorage, AK 99512
   Phone: 907-265-8871

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Suggested Activities

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Print Reading and Layout for Pipe Welding
Unit 2

Answers to Assignment Sheets

Assignment Sheet 1

a. $x = 3.6055''$ or $3\frac{39}{64}''$
b. $x = 79.2630''$ or $6' - 7\frac{17}{64}''$
c. $a = 5.1960''$ or $5\frac{3}{16}''$
$x = 6.000''$ or $6''$
d. $a = 46.6692''$ or $3' - 10\frac{21}{32}''$
$b = 46.6692''$ or $3'\ 10\frac{21}{32}''$
e. $a = 108.4166''$ or $9' - 5''$
$x = 153.3227''$ or $12' - 9\frac{21}{64}''$
f. $a = 167.2029''$ or $13' - 11''\frac{13}{64}''$
$x = 243.7438''$ or $20' - 3\frac{3}{4}''$

Assignment Sheet 2

a. $X = 60^\circ$
b. $X = 49^\circ\ 45'$
c. $A = 30^\circ$
$X = 60^\circ$
d. $A = 63^\circ\ 26'$
$B = 26^\circ\ 34'$
e. $A = 60^\circ$
$B = 60^\circ$

Print Reading and Layout for Pipe Welding
Unit 2

Answers to Written Test

1. a. 3
   b. 5
   c. 6
   d. 1
   e. 4
   f. 2

2. a. Double line
   b. Single line

3. a. Standardized
   b. Materials
   c. Joints

4. a. 4
   b. 5
   c. 1
   d. 2
   e. 6
   f. 7
   g. 3
   h. 8

5. a. Centerline to centerline
   b. Centerline to face

6. a. Types
   b. Procedure

7. a. 3
   b. 1
   c. 2

8. a, b, c, d

9. a. Extend
   b. Unknown, unknown
   c. Easy

10. a, c, d, e, g, h

11. a. 5
    b. 2
    c. 3 (or 4)
    d. 4 (or 3)
    e. 1

12. 60°

Answers to Written Test

13. a. Size
    b. Outside
    c. Wall thickness
    d. Inches

14. a. 5
    b. 9
    c. 10
    d. 8
    e. 6
    f. 3
    g. 11
    h. 1
    i. 7
    j. 4
    k. 2

Print Reading and Layout for Pipe Welding
Unit 2

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

_____a. A triangle with one right angle

_____b. The side or a right triangle opposite the right angle

_____c. The study of properties of triangles and their functions

_____d. The relationship of an arc or angle expressed as a ration of pairs of sides of a right triangle

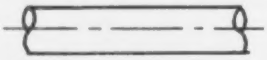
_____e. A type of drawing commonly used in pipe prints to present a pipe application in a perspective based on equal angles

_____f. A pattern for forming an accurate copy of an object or shape

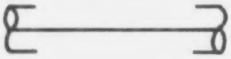
1. Trigonometric function
2. Template
3. Right triangle
4. Isometric drawing
5. Hypotenuse
6. Trigonometry

2. Identify methods for presenting pipe on blueprints by placing the correct method name beside each of the following illustrations.

_______________a.



_______________b.



Written Test

3. Complete statements about pipe symbols and their uses. Circle the material that best completes each of the following statements.

   a. Symbols present components of piping systems in a (**standardized**) (**graphic**) manner that can be readily interpreted by a welder.

   b. Symbols indicate types and locations of fittings and piping requirements so correct (**equipment**) (**materials**) can be ordered for the job.

   c. Symbols indicate with a prominently placed dot the location of (**bends**) (**joints**) where welds should be made.

4. Match the common pipe symbols on the right with their correct meanings. Place the number of the symbol in the appropriate blank.

______a. A cap at the end of a line to cap off or stop line flow

______b. A 90° elbow used to make a 90° turn in a line

______c. A 45° elbow used to make a 45° turn in a line

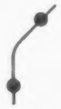
______d. A tee used to indicate a 90° take-off from a line

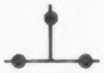
______e. Crosses used to indicate where lines intersect each other

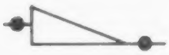
______f. A concentric reducer used to indicate that a pipe should be reduced but maintain the same center line

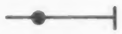
______g. An eccentric reducer used to indicate that a pipe should be reduced but maintain the same flow line

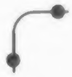
______h. A flange used to indicate a pipe separation for a bolt-on component such as a valve or a meter

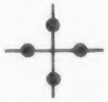
1. 

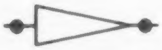
2. 

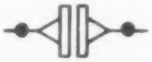
3. 

4. 

5. 

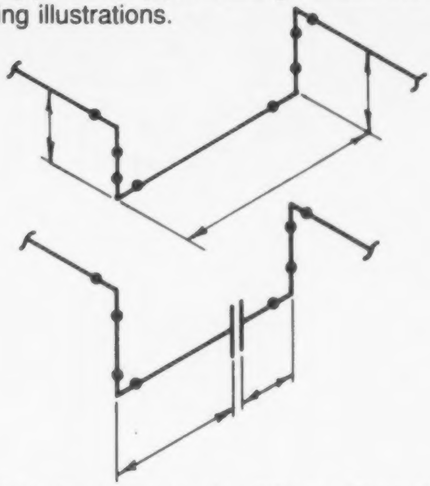
6. 

7. 

8. 

Written Test

5. Identify methods for dimensioning prints for pipe welding. Place the correct method name beside each of the following illustrations.



__________________a.

__________________b.

6. Complete statements about symbols for common pipe fittings. Circle the material that best completes each of the following statements.

   a. Symbols indicate (**sizes**) (**types**) of fittings.

   b. Symbols indicate the (**procedure**) (**materials required**) for joining with other components.

7. Match the special welded fittings on the right with their uses.

   ______a. A fitting with a saddle on one end and a threaded opening on the other end so that the saddled end can be welded onto a main line and a threaded pipe can be used on the other end to complete a take-off

   ______b. A fitting with a saddle on one end and a socket on the other end so that the saddled end can be welded onto a main line and the take-off can be completed with another welded joint

   ______c. A fitting with a saddle on one end and a beveled edge on the other so that the saddle can be welded onto a main line and the tie-in for a take-off can be made without cutting into a welded tee fitting

   1. Socket outlet
   2. Welded outlet
   3. Threaded outlet

Written Test

8. Select true statements about advantages of isometric drawings for pipe welding prints. Place an "X" beside each true statement.

   ______a. Isometric drawings make it easier to form a mental picture of the relationship of components in a piping installation.

   ______b. Isometric drawings provide complete pictorial representation of pipe sizes, fittings, dimensions, and notes to clarify material specifications or procedures.

   ______c. Isometric drawings use standard symbols to indicate joints and component applications at joints.

   ______d. Isometric drawings are usually complete with a bill of material which lists size and types of pipes, components and standards with which they must comply, vital testing specifications, and notes for clarification.

9. Complete the following statements about functions of a right triangle. Circle the material that best completes each of the following statements.

   a. Lines, arcs, and angles extended from a triangle form functions as they converge or (**stop**) (**extend**).

   b. Right triangle functions can be used to determine (**other**) (**unknown**) angles and (**other**) (**unknown**) line lengths.

   c. Functions in a right triangle are (**difficult**) (**easy**) to work with and handy to know and remember.

10. Select true statements about guidelines for solving trigonometric problems. Place an "X" beside each true statement.

    ______a. A triangle has three sides and three angles.

    ______b. The angles in a triangle add up to 360°.

    ______c. If one side and two angles are known, the other angle and the other two sides can be found.

    ______d. If two sides and one angle are known, the other two angles and the other side can be found.

    ______e. If all three sides are known, the angles can be found.

    ______f. If only the three angles are know, the sides can be found.

Written Test

______g. If two angles are know, add them together and subtract from 180° to find the other angle.

______h. If the two sides forming the right angle of a right triangle are known, the hypotenuse can be found using the following formula: $c = \sqrt{a^2 + b^2}$.

11. Arrange in order the steps in laying out angles on 90° long radius elbows. Place a "1" beside the first step, a "2" beside the second step, etc.

______a. Wrap tape around elbow and mark cutting line.

______b. Determine elbow angle.

______c. Measure distance on outside arc.

______d. Measure distance on inside arc.

______e. Measure diameter of pipe and determine distance of outside and inside arcs from arc length tables.

12. Solve the following problem using the 12-inch rule for finding angles with a steel square.

Problem: A 33″ distance from the bend point to the 12″ distance on the angular take-off of a pipe would indicate an angle of what degrees?

Answer: ______________________________

Note: Use the following chart to help determine the correct answer.

Degree of Angle	Cotangent	Distance by 12-Inch Rule
	11.43005	137″
	5.67128	68″
	3.73205	44¾″
	2.74748	33″
	2.41421	29″
	1.73205	20¾″
	1.0000	12″
	0.57735	7″

Written Test

13. Complete statements about standard references for commercial pipe identification. Circle the material that best completes each of the following statements.

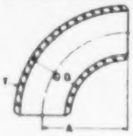
    a. Nominal pipe (**length**) (**size**)

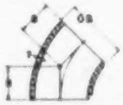
    b. (**Inside**) (**Outside**) diameter is more exact.

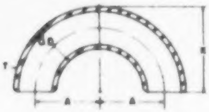
    c. (**Diameter**) (**Wall thickness**) for schedule number

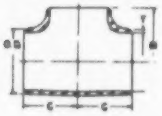
    d. Dimensions stated in (**millimeters**) (**inches**)

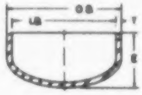
14. Match standard weld fittings with their shapes. Place the number of the fitting in the blank beside the correct shape.

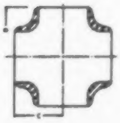
_______a. 

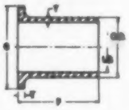
_______b. 

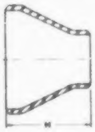
_______c. 

_______d. 

_______e. 

_______f. 

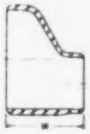
_______g. 

_______h. 

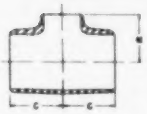
1. Concentric reducers
2. Welding neck flanges
3. Crosses
4. Reducing outlet tees
5. 90° elbows
6. Caps
7. Eccentric reduces
8. Tees
9. 45° elbows
10. 180° returns
11. Stub ends

Written Test

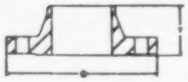
_______i.



_______j.



_______k.



*Permission to duplicate this test is granted.

Print Reading and Layout for Pipe Welding
Unit 2

Unit Evaluation Form

Student Name ______________________________ Unit Rating ____________

Assignment Sheet 1—Solve Trigonometry Problems for Unknown Sides Rating ______

Comments: ____

____

Assignment Sheet 2—Solve Trigonometry Problems for Unknown Angles Rating ______

Comments: ____

____

Job Sheet 1—Develop a Template for a 90° Turn Rating ______

Comments: ____

____

Job Sheet 2—Develop a Template for a 90° Branch
With Pipes of Equal Size Rating ______

Comments: ____

____

Job Sheet 3—Develop a Template for a 45° Branch Connection Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

***Permission to duplicate this form is granted.**

Print Reading and Layout for Pipe Welding
Unit 2

Information Sheet

1. **Terms and definitions**

    a. **Right triangle** — A triangle with one right angle

    b. **Hypotenuse** — The side of a right triangle opposite the right angle

    c. **Trigonometry** — The study of properties of triangles and their functions

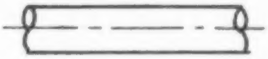
    d. **Trigonometric function** — The relationship of an arc or angle expressed as a ration of pairs of sides of a right triangle

    e. **Isometric drawing** — A type of drawing commonly used in pipe prints to present a pipe application in a perspective based on equal angles

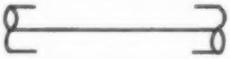
    f. **Template** — A pattern for forming an accurate copy of an object or shape

2. **Methods of presenting pipe on blueprints**

    a. **Double line** — Normally used to present pipes with diameters of 12″ or more



    b. **Single line** — Normally used to present pipes with diameters that range from 2″ through 11″



3. **Piping symbols and their uses**

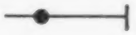
    a. Symbols present components of piping systems in a standardized manner that can be readily interpreted by a welder.

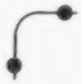
    b. Symbols indicate types and locations of fittings and piping requirements so correct materials can be ordered for the job.

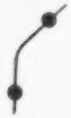
    c. Symbols indicate with a prominently placed dot the location of joints where welds should be made.

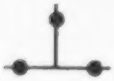
Information Sheet

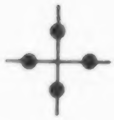
4. Common piping symbols and their meanings

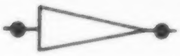
a.  — A cap at the end of a line to cap off or stop line flow

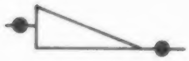
b.  — A 90° elbow used to make a 90° turn in a line

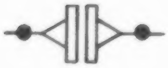
c.  — A 45° elbow used to make a 45° turn in a line

d.  — A tee used to indicate a 90° take-off from a line

e.  — Crosses used to indicate where lines intersect each other

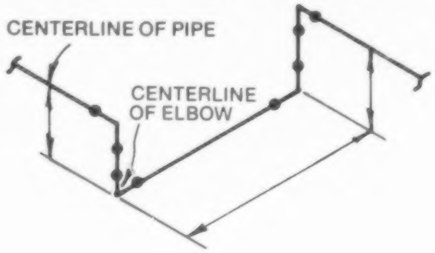
f.  — A concentric reducer used to indicate that a pipe should be reduced but maintain the same center line

g.  — An eccentric reducer used to indicate that a pipe should be reduced but maintain the same flow line

h.  — A flange used to indicate a pipe separation for a bolt-on component such as a valve or a meter

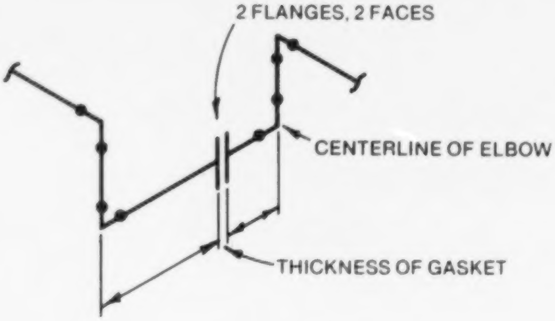
5. Methods for dimensioning prints for pipe welding

a. **Centerline to centerline** — Indicates dimensions from the centerline of one component to the centerline of an adjacent component



Information Sheet

b. **Centerline to face** — Indicates dimensions measured from the centerline of a pipe to the face of an adjacent flange



6. **Symbols for common pipe fittings**

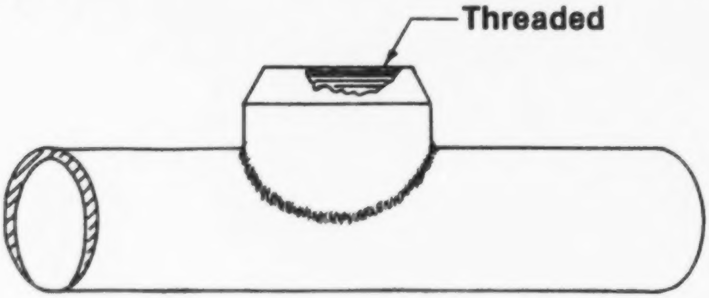
a. Symbols indicate types of fittings.

b. Symbols indicate the procedure for joining with other components.

Note: Even in installations where some fittings are welded, other fittings may be flanged, screwed, or soldered. Student Supplement 1 details symbols for various applications.

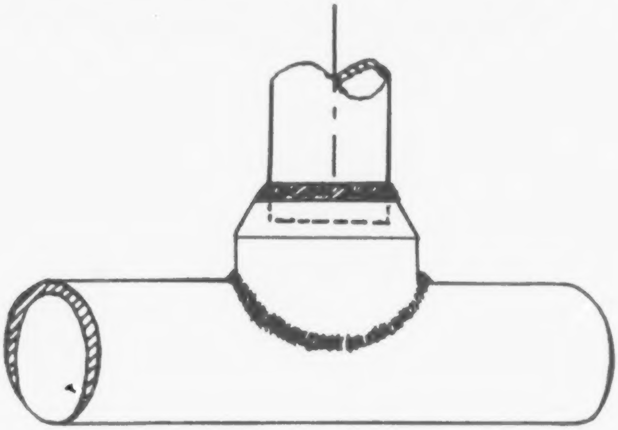
7. **Special welded fittings and their uses**

a. **Threaded outlet (threadolet)** — A fitting with a saddle on one end and a threaded opening on the other end so that the saddled end can be welded onto a main line and a threaded pipe can be used on the other end to complete a take-off

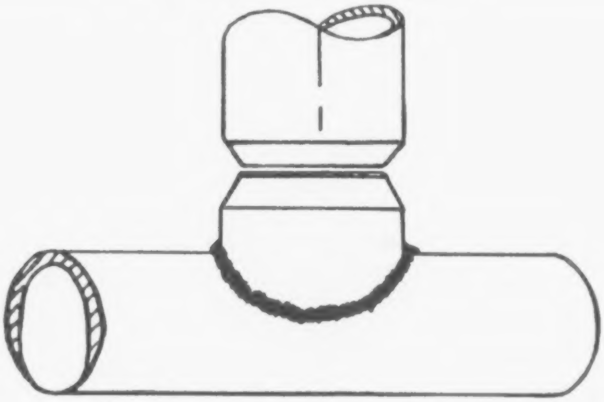


Information Sheet

b. **Socket outlet (sockolet)** — A fitting with a saddle on one end and a socket on the other end so that the saddled end can be welded onto a main line and the take-off can be completed with another welded joint



c. **Welded outlet (weldolet)** — A fitting with a saddle on one end and a beveled edge on the other so that the saddle can be welded onto a main line and the tie-in for a take-off can be made without cutting into a welded tee fitting

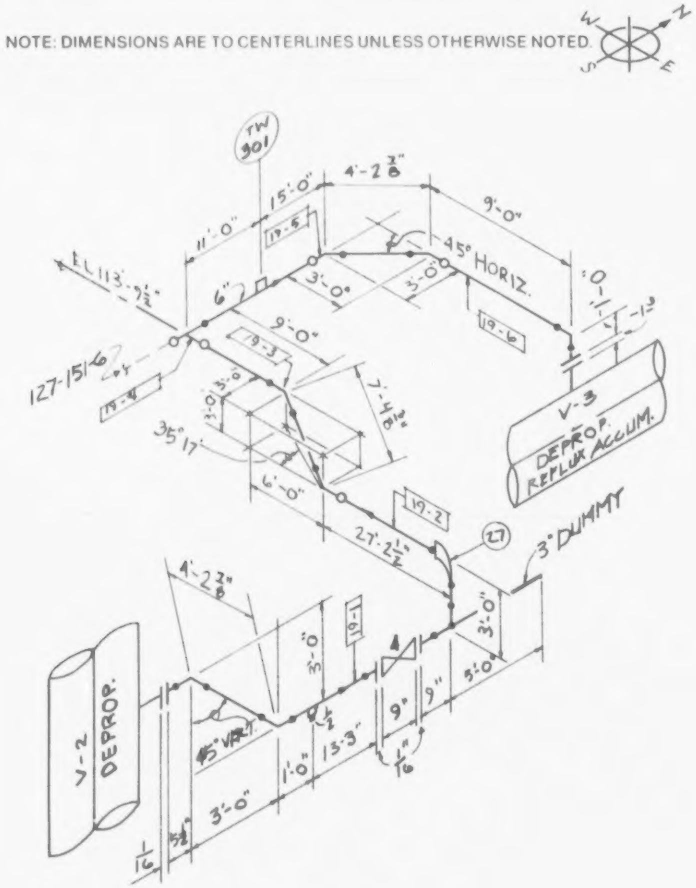


Information Sheet

8. Advantages of isometric drawings for pipe welding prints

a. Isometric drawings make it easier to form a mental picture of the relationship of components in a piping installation.

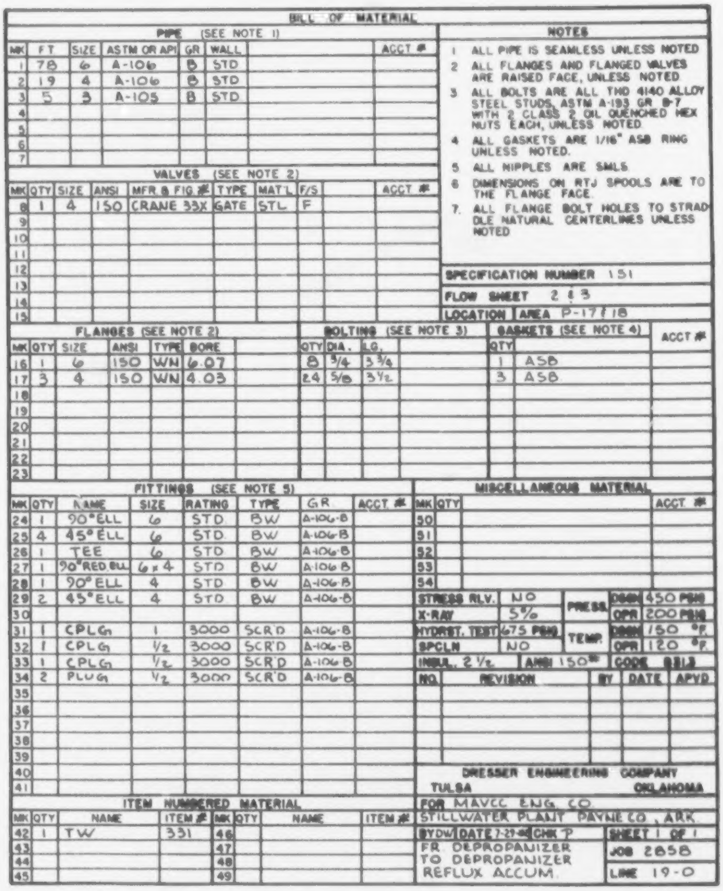
b. Isometric drawings provide complete pictorial representation of pipe sizes, fittings, dimensions, and notes to clarify material specifications or procedures.


NOTE: DIMENSIONS ARE TO CENTERLINES UNLESS OTHERWISE NOTED.
W
N
S
E
TW 301
15'-0"
4'-2 3/8"
9'-0"
11'-0"
19-5
45° HORIZ.
EL 113'-9 1/2"
6"
3'-0"
3'-0"
19-6
1'-0"
1 3/8"
9'-0"
19-3
127-151-6
19-4
3'-0"
3'-0"
7'-4 9/16"
35°17'
6'-0"
V-3
DEPROP.
REFLUX ACCUM.
19-2
27'-2 1/2"
27
3" DUMMY
4'-2 3/8"
3'-0"
19-1
3'-0"
V-2
DEPROP.
45° VERT.
1/2
13'-3"
9"
9"
5'-0"
1'-0"
1/16
3'-0"
1/16
5/32

c. Isometric drawings use standard symbols to indicate joints and component applications at joints.

Information Sheet

d. Isometric drawings are usually complete with a bill of material which lists size and types of pipes, components and standards with which they must comply, vital testing specifications, and notes for clarification.



BILL OF MATERIAL

PIPE (SEE NOTE 1)							
MK	FT	SIZE	ASTM OR API	GR	WALL		ACCT #
1	78	6	A-106	B	STD		
2	19	4	A-106	B	STD		
3	5	3	A-105	B	STD		
4							
5							
6							
7							

VALVES (SEE NOTE 2)									
MK	QTY	SIZE	ANSI	MFR & FIG #	TYPE	MAT'L	F/S		ACCT #
8	1	4	150	CRANE 33X	GATE	STL	F		
9									
10									
11									
12									
13									
14									
15									

NOTES

1. ALL PIPE IS SEAMLESS UNLESS NOTED
2. ALL FLANGES AND FLANGED VALVES ARE RAISED FACE, UNLESS NOTED
3. ALL BOLTS ARE ALL THD 4140 ALLOY STEEL STUDS, ASTM A-193 GR B-7 WITH 2 CLASS 2 OIL QUENCHED HEX NUTS EACH, UNLESS NOTED
4. ALL GASKETS ARE 1/16" ASB RING UNLESS NOTED.
5. ALL NIPPLES ARE SMLS
6. DIMENSIONS ON RTJ SPOOLS ARE TO THE FLANGE FACE
7. ALL FLANGE BOLT HOLES TO STRADDLE NATURAL CENTERLINES UNLESS NOTED

SPECIFICATION NUMBER 151

FLOW SHEET 2 & 3

LOCATION AREA P-17 & 18

FLANGES (SEE NOTE 2)							BOLTING (SEE NOTE 3)				GASKETS (SEE NOTE 4)		ACCT #
MK	QTY	SIZE	ANSI	TYPE	BORE		QTY	DIA.	LG.		QTY		
16	1	6	150	WN	6.07		8	3/4	3 3/4		1	ASB	
17	3	4	150	WN	4.03		24	5/8	3 1/2		3	ASB	
18													
19													
20													
21													
22													
23													

FITTINGS (SEE NOTE 5)							
MK	QTY	NAME	SIZE	RATING	TYPE	GR	ACCT #
24	1	90° ELL	6	STD	BW	A-106-B	
25	4	45° ELL	6	STD	BW	A-106-B	
26	1	TEE	6	STD	BW	A-106-B	
27	1	90° RED ELL	6 x 4	STD	BW	A-106-B	
28	1	90° ELL	4	STD	BW	A-106-B	
29	2	45° ELL	4	STD	BW	A-106-B	
30							
31	1	CPLG	1	3000	SCR'D	A-106-B	
32	1	CPLG	1/2	3000	SCR'D	A-106-B	
33	1	CPLG	1/2	3000	SCR'D	A-106-B	
34	2	PLUG	1/2	3000	SCR'D	A-106-B	
35							
36							
37							
38							
39							
40							
41							

MISCELLANEOUS MATERIAL			
MK	QTY		ACCT #
50			
51			
52			
53			
54			

STRESS RLV.	NO	PRESS.	DSGN	450 PSIG
X-RAY	5%		OPR	200 PSIG
HYDRST. TEST	675 PSIG	TEMP.	DSGN	150 °F.
SPCLN	NO		OPR	120 °F.
INSUL. 2 1/2	ANSI 150#		CODE	B31.3

NO.	REVISION	BY	DATE	APVD

ITEM NUMBERED MATERIAL							
MK	QTY	NAME	ITEM #	MK	QTY	NAME	ITEM #
42	1	TW	331	46			
43				47			
44				48			
45				49			

DRESSER ENGINEERING COMPANY
TULSA OKLAHOMA

FOR MAVCC ENG. CO.
STILLWATER PLANT PAYNE CO., ARK.
BY DW DATE 7-29-[illegible] CHK P SHEET 1 OF 1
FR DEPROPANIZER
TO DEPROPANIZER
REFLUX ACCUM.
JOB 2858
LINE 19-0

9. **Functions of a right triangle**

a. Lines, arcs, and angles extended from a triangle form functions as they converge or extend.

b. Right triangle functions can be used to determine unknown angles and unknown line lengths.

Information Sheet

c. Functions in a right triangle are easy to work with and handy to know and remember.

(1) Sine (SIN)

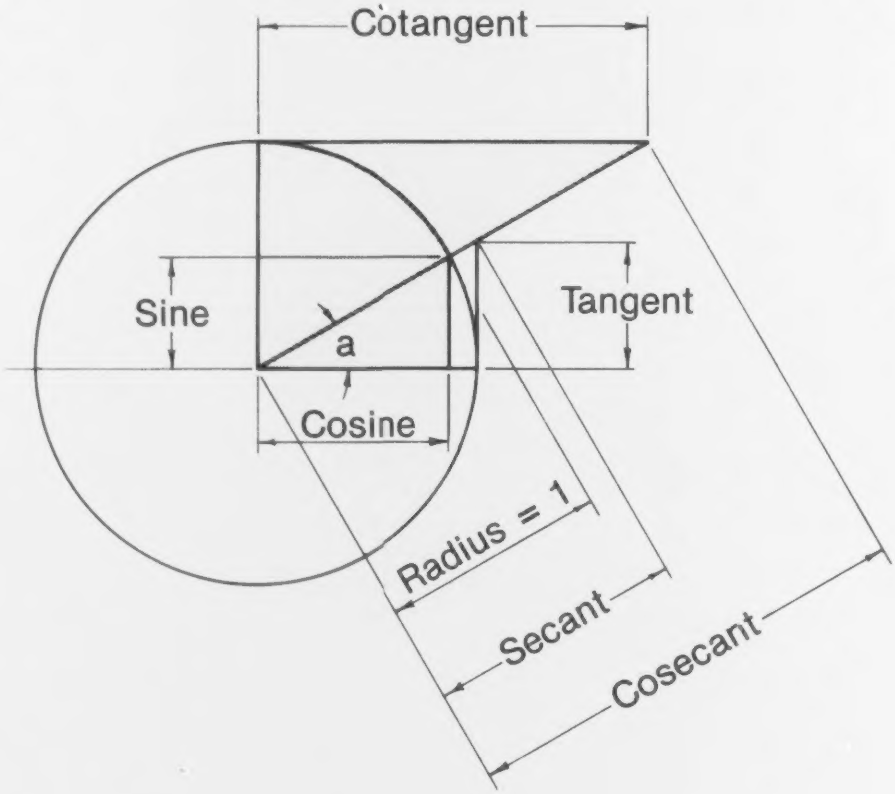
(2) Cosine (COS)

(3) Tangent (TAN)

(4) Contangent (COTAN)

(5) Secant (SEC)

(6) Cosecant (COSEC)


Cotangent
Sine
a
Tangent
Cosine
Radius = 1
Secant
Cosecant

Information Sheet

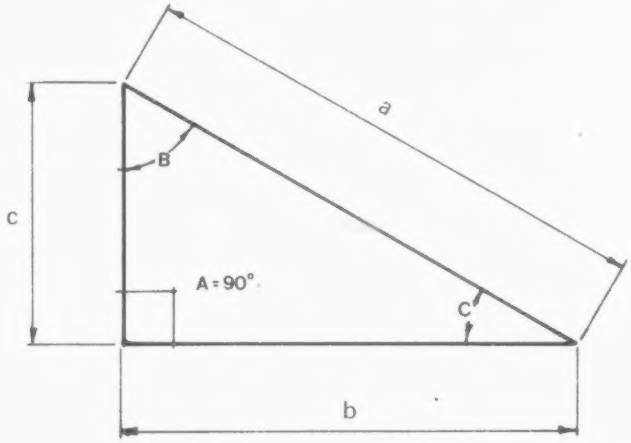
10. Guidelines for solving trigonometric problems

a. A triangle has three sides and three angles.

b. The angles in a triangle add up to 180°.

c. If one side and two angles are known, the other angle and the other two sides can be found.

Example: Given — A = 90°, B = 30° c = 3″
Unknown — a = ______, b = ______, C = ______



(1) To find angle C:

C = 180° − (A = B)

C = 180° − (90° + 30°)

C = 180° − (120°)

C = 60°

(2) To find side b:

b = c × TAN B

b = 3″ × TAN 30°

Note: Determine the tangent of 30° using a trig function book or a calculator provided by instructor.

Information Sheet

b = 3″ × .57735

b = 1.73205″

b = $1\frac{49}{64}$″

(3) To find side a:

a = c × COSEC C

a = 3″ × COSEC 60°

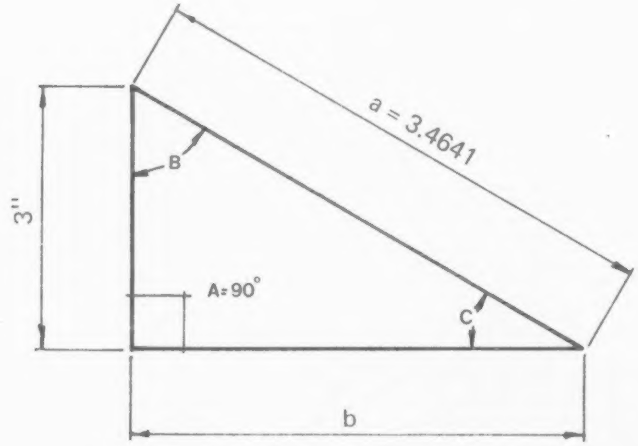
a = 3″ × 1.1547

a = 3.4641″

a = $3\frac{15}{32}$″

d. If two sides and one angle are known, the other two angles and the other side can be found.

Example: Given — A = 90°, c = ″, a = 3.4641″
Unknowns — B = ______, C = ______, b = ______



(1) To find angle B:

$$B = \frac{c}{a} = \text{COS B}$$

Information Sheet

$B = \frac{3}{a} = \text{COS } B$

$B = \frac{3}{3.4641} = \text{COS } B$

$B = 3.4641 \ 3 = \text{COS } B$

$B = .86603 = \text{COS } B$

$B = 30^\circ$

(2) To find angle C:

$C = 180^\circ - (A + B)$

$C = 180^\circ - (90^\circ + 30^\circ)$

$C = 180^\circ - (120^\circ)$

$C = 60^\circ$

(3) To find side b:

$b = a \times \text{SIN } B$

$b = 3.4641 \times \text{SIN } B$

$b = 3.4641 \times \text{SIN } 30^\circ$

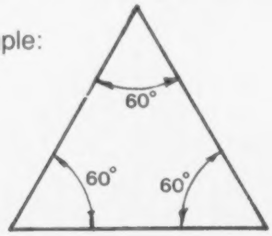
$b = 3.4641 \times .50000$

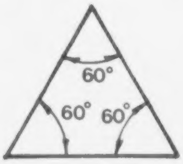
$b = 1.73205$

e. If all three sides are known, the angles can be found.

f. If only the three angles are known, the sides cannot be found.

Example:





Information Sheet

g. If two angles are known, add them together and subtract from 180° to find the other angle.

Example: Known — $A = 40^\circ$, $B = 40^\circ$, then $180^\circ - 80^\circ = 100^\circ$

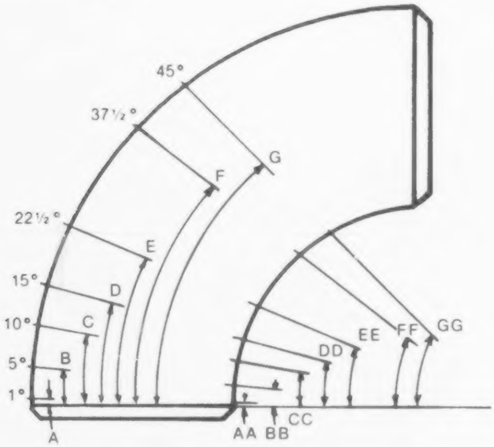
h. If the two sides forming the right angle of a right triangle are known, the hypotenuse can be found using the following formula:

$$c = \sqrt{a^2 + b^2}$$

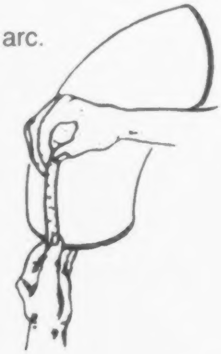
11. Steps in laying out angles on 90° long radius elbows

a. Measure diameter of pipe and determine distance of outside and inside arcs from arc length tables.

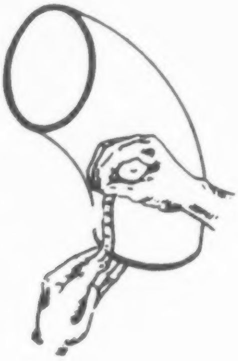
b. Determine elbow angle.



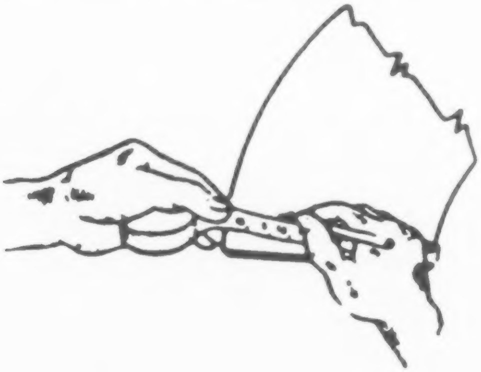
c. Measure distance on outside arc.



d. Measure distance on inside arc.



e. Wrap tape around elbow and mark cutting line.



12. The 12-inch rule for finding angles with a steel square

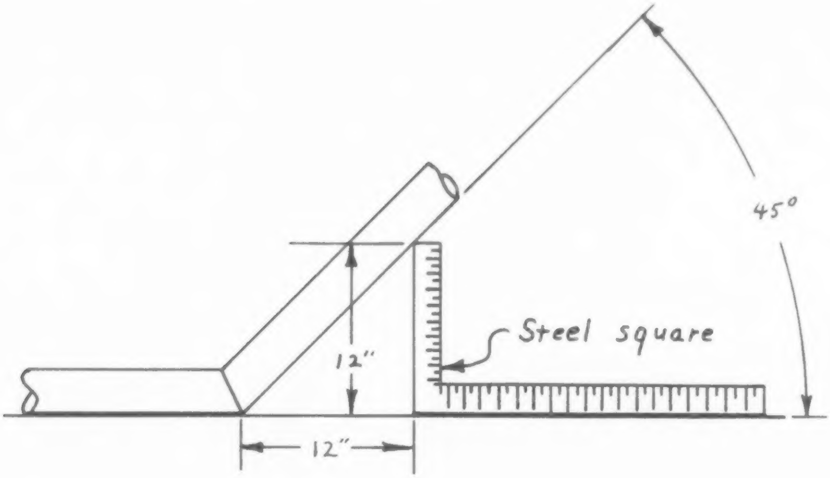
a. The distance from the bend point of a pipe to a point on the angular take-off that measures 12″ will indicate the angle, and this is known as the 12-inch rule.

Note: Using the 12-inch rule properly will produce close-to-accurate results, but measurements will usually have a plus or minus factor.

Information Sheet

b. Angles are easy to obtain by multiplying the cotangent of the angle by 12″.

Example: The cotangent of 45° is 1.000
1.000 × 12″ = 12″
The 12″ distance from the bend point to the 12″ distance on the angular take-off indicates a 45° point.

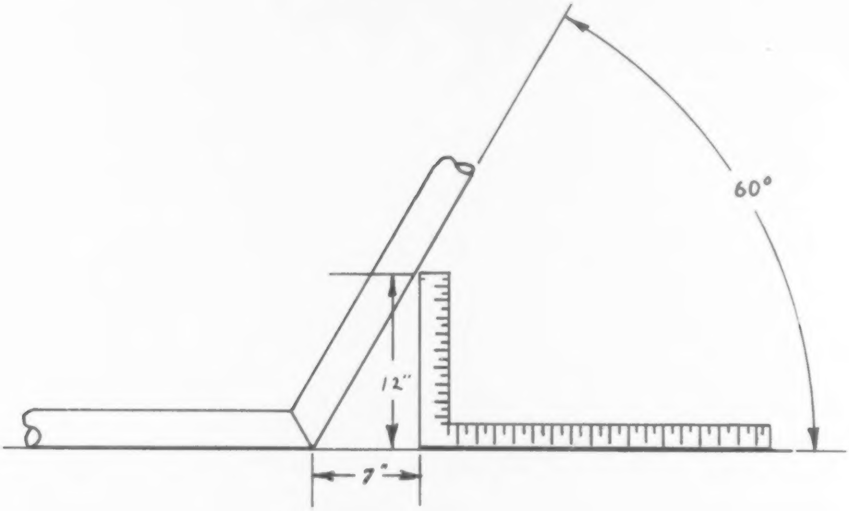


c. Common angles, cotangents, and 12-inch rule distances are:

Degree of Angle	Cotangent	Distance by 12-Inch Rule
5°	11.43005	137″
10°	5.67128	68″
15°	3.73205	44¾″
20°	2.74748	33″
22½°	2.41421	29″
30°	1.73205	20¾″
45°	1.0000	12″
60°	0.57735	7″

Information Sheet

Example: The cotangent of 60° is .57735
.57735 × 12″ = 6.9282″ or 7″
The 7″ distance from the bend point to the 12″ distance on the angular take-off indicates a 60° angle.



13. Standard references for commercial pipe identification

a. Nominal pipe size

b. Outside diameter is more exact.

c. Wall thickness for schedule number

Information Sheet

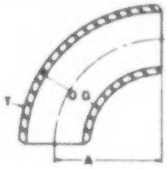
d. Dimensions stated in inches

NOMINAL PIPE SIZE	OUTSIDE DIAM.	THICKNESS FOR								
		SCHED. 40	SCHED. 60	EXTRA STRONG	SCHED. 80	SCHED. 100	SCHED. 120	SCHED. 140	SCHED. 160	XX STRONG
⅛	0.405	0.068	—	0.095	0.095	—	—	—	—	—
¼	0.540	0.088	—	0.119	0.119	—	—	—	—	—
⅜	0.675	0.091	—	0.126	0.126	—	—	—	—	—
½	0.840	0.109	—	0.147	0.147	—	—	—	0.188	0.294
¾	1.050	0.113	—	0.154	0.154	—	—	—	0.219	0.308
1	1.315	0.133	—	0.179	0.179	—	—	—	0.250	0.358
1¼	1.660	0.140	—	0.191	0.191	—	—	—	0.250	0.382
1½	1.900	0.145	—	0.200	0.200	—	—	—	0.281	0.400
2	2.375	0.154	—	0.218	0.218	—	—	—	0.344	0.436
2½	2.875	0.203	—	0.276	0.276	—	—	—	0.375	0.552
3	3.5	0.216	—	0.300	0.300	—	—	—	0.438	0.600
3½	4.0	0.226	—	0.318	0.318	—	—	—	—	—
4	4.5	0.237	—	0.337	0.337	—	0.438	—	0.531	0.674
5	5.563	0.258	—	0.375	0.375	—	0.500	—	0.625	0.750
6	6.625	0.280	—	0.432	0.432	—	0.562	—	0.719	0.864
8	8.625	0.322	0.406	0.500	0.500	0.594	0.719	0.812	0.906	0.875
10	10.75	0.365	0.500	0.500	0.594	0.719	0.844	1.000	1.125	1.000
12	12.75	0.406	0.562	0.500	0.688	0.844	1.000	1.125	1.312	1.000
14 O.D.	14.0	0.438	0.594	0.500	0.750	0.938	1.094	1.250	1.406	—
16 O.D.	16.0	0.500	0.656	0.500	0.844	1.031	1.219	1.438	1.594	—
18 O.D.	18.0	0.562	0.750	0.500	0.938	1.156	1.375	1.562	1.781	—
20 O.D.	20.0	0.594	0.812	0.500	1.031	1.281	1.500	1.750	1.969	—
22 O.D.	22.0	—	0.875	0.500	1.125	1.375	1.625	1.875	2.125	—
24 O.D.	24.0	0.688	0.969	0.500	1.218	1.531	1.812	2.062	2.344	—
26 O.D.	26.0	—	—	0.500	—	—	—	—	—	—
28 O.D.	28.0	—	—	0.500	—	—	—	—	—	—
30 O.D.	30.0	—	—	0.500	—	—	—	—	—	—
32 O.D.	32.0	0.688	—	0.500	—	—	—	—	—	—
34 O.D.	34.0	0.688	—	0.500	—	—	—	—	—	—
36 O.D.	36.0	0.750	—	0.500	—	—	—	—	—	—
42 O.D.	42.0	—	—	0.500	—	—	—	—	—	—

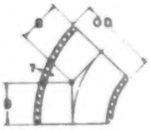
Information Sheet

14. Standard weld fittings and their shapes

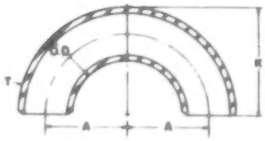
a. 90° elbows



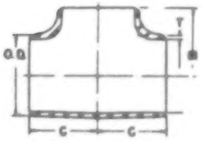
b. 45° elbows



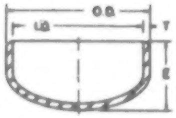
c. 180° returns



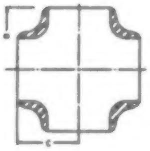
d. Tees



e. Caps

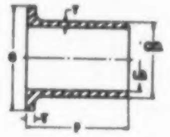


f. Crosses

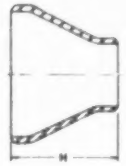


Information Sheet

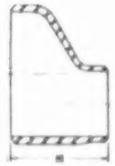
g. Stub ends



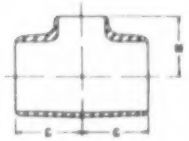
h. Concentric reducers



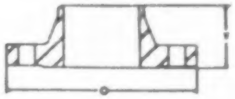
i. Eccentric reduces



j. Reducing outlet tees

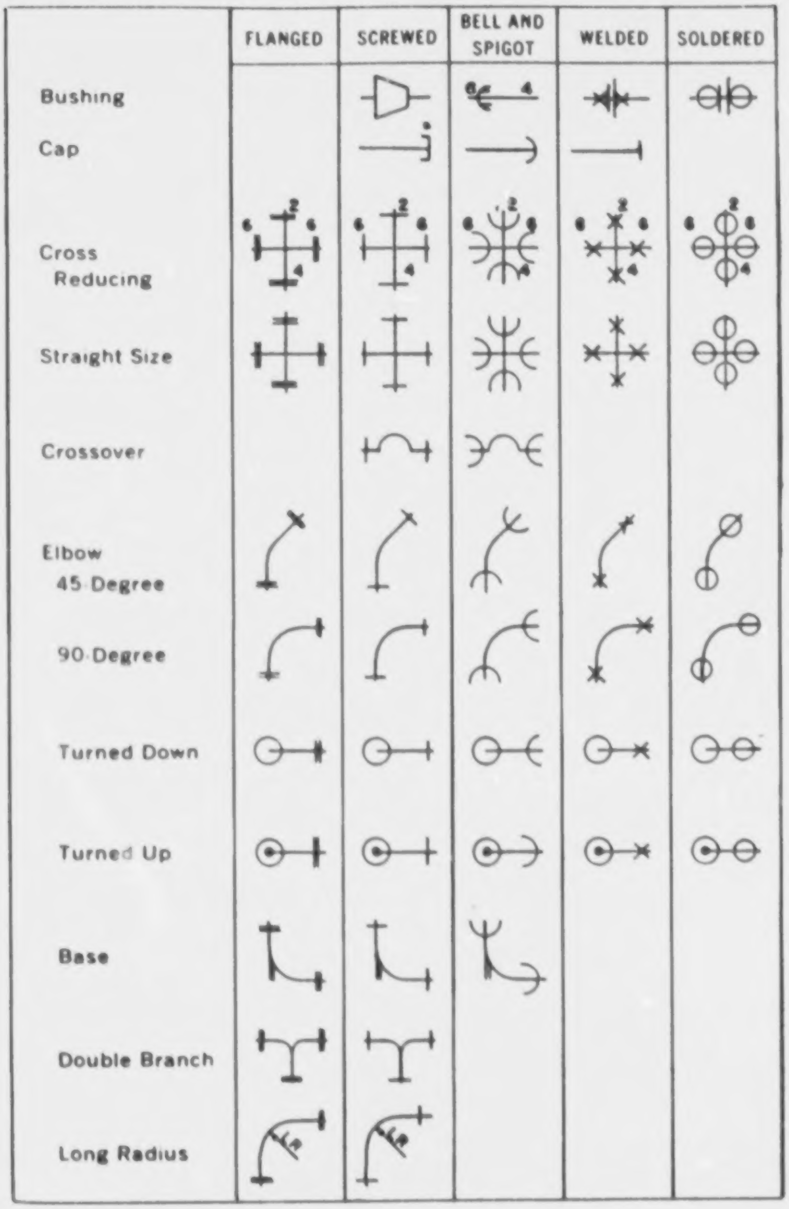


k. Welding neck flanges



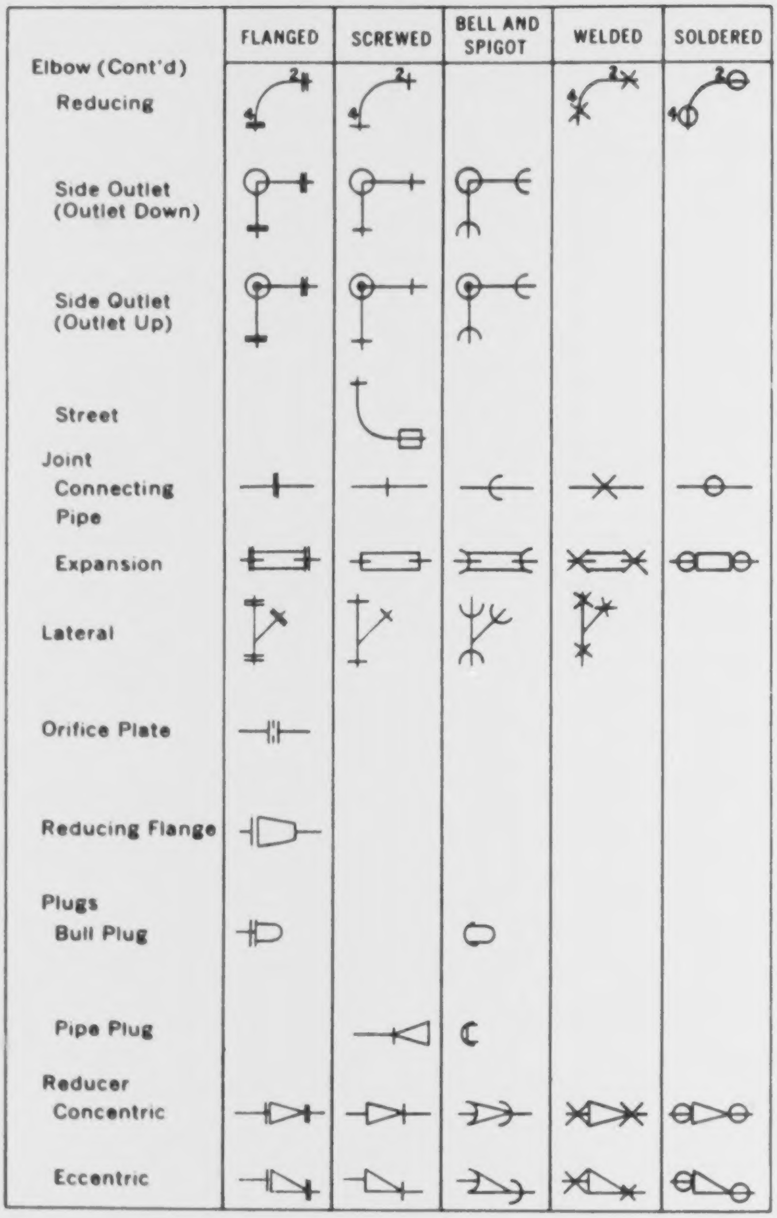
Print Reading and Layout for Pipe Welding
Unit 2

Student Supplement 1—Symbols for Common Pipe Fittings


FLANGED
SCREWED
BELL AND SPIGOT
WELDED
SOLDERED
Bushing
Cap
Cross
Reducing
Straight Size
Crossover
Elbow
45 Degree
90 Degree
Turned Down
Turned Up
Base
Double Branch
Long Radius
6
2
4

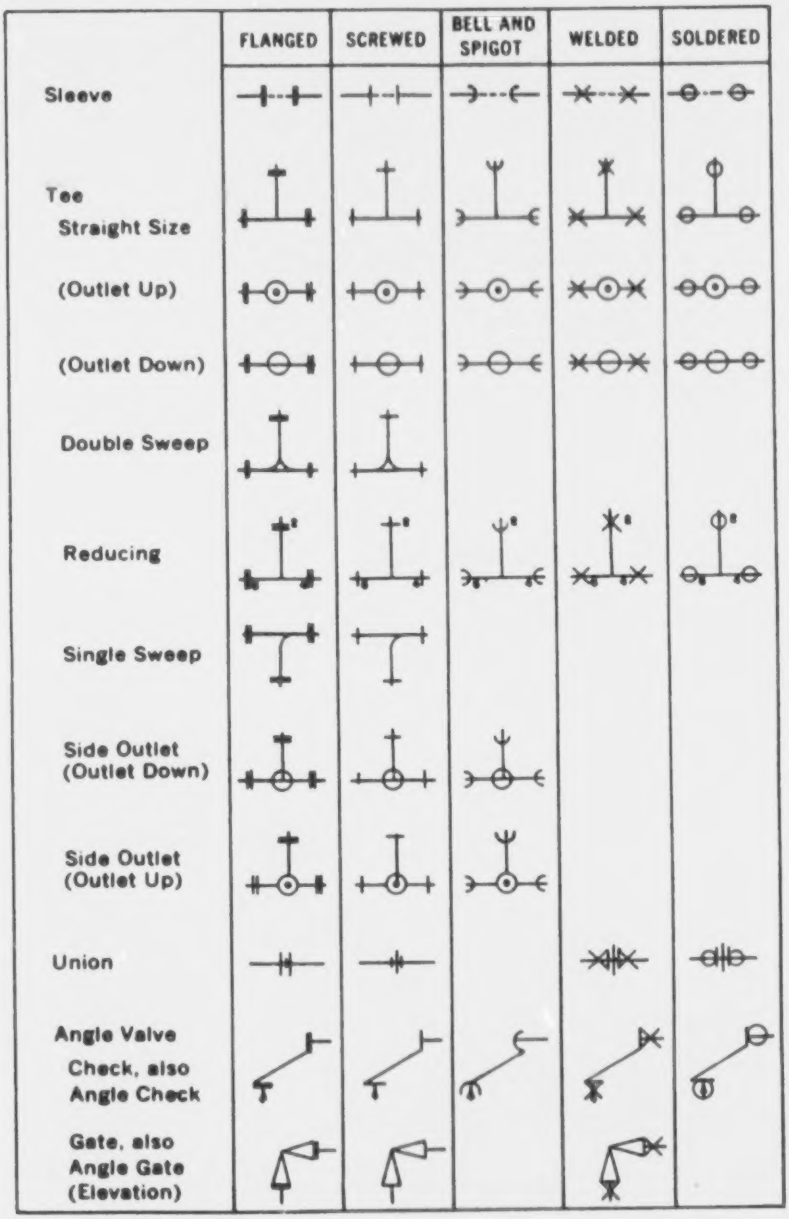
Courtesy Dearman International, Inc.

Student Supplement 1


FLANGED
SCREWED
BELL AND SPIGOT
WELDED
SOLDERED
Elbow (Cont'd)
Reducing
2
4
Side Outlet (Outlet Down)
Side Outlet (Outlet Up)
Street
Joint
Connecting Pipe
Expansion
Lateral
Orifice Plate
Reducing Flange
Plugs
Bull Plug
Pipe Plug
Reducer
Concentric
Eccentric

Courtesy Dearman International, Inc.

Student Supplement 1


FLANGED
SCREWED
BELL AND SPIGOT
WELDED
SOLDERED
Sleeve
Tee
Straight Size
(Outlet Up)
(Outlet Down)
Double Sweep
Reducing
Single Sweep
Side Outlet (Outlet Down)
Side Outlet (Outlet Up)
Union
Angle Valve
Check, also Angle Check
Gate, also Angle Gate (Elevation)

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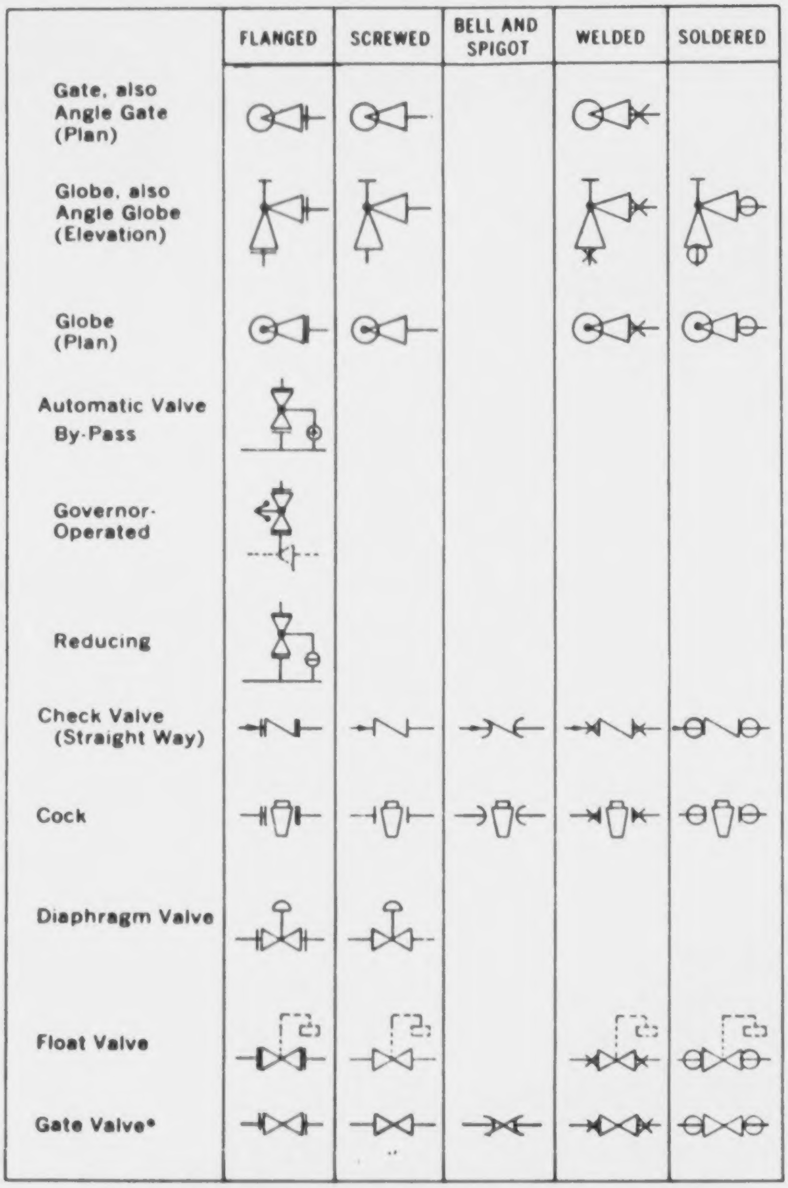
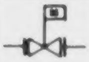
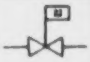
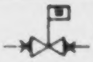
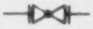
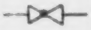
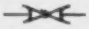
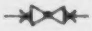
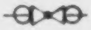
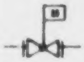
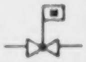
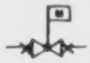
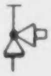
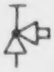
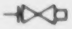
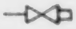
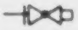
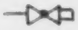
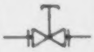
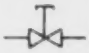
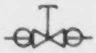
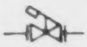
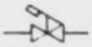
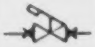
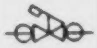
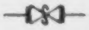
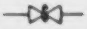
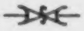
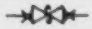
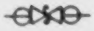
Student Supplement 1


FLANGED
SCREWED
BELL AND SPIGOT
WELDED
SOLDERED
Gate, also Angle Gate (Plan)
Globe, also Angle Globe (Elevation)
Globe (Plan)
Automatic Valve By-Pass
Governor-Operated
Reducing
Check Valve (Straight Way)
Cock
Diaphragm Valve
Float Valve
Gate Valve*

*Also used for General Stop Valve Symbol when amplified by specification.

Courtesy Dearman International, Inc.

Student Supplement 1

	FLANGED	SCREWED	BELL AND SPIGOT	WELDED	SOLDERED
Motor-Operated					
Globe Valve					
Motor-Operated					
Hose Valve, also Hose Globe Angle, also Hose Angle					
Gate					
Globe					
Lockshield Valve					
Quick Opening Valve					
Safety Valve					

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Print Reading and Layout for Pipe Welding
Unit 2

Student Supplement 2—Arc Lengths for 90° Long Radius Elbows

NOM SIZE	OUTSIDE ARC						
	A	B	C	D	E	F	G
2	5/64	3/8	23/32	1 3/32	1 21/32	2 3/4	3 9/32
2 1/2	3/32	7/16	29/32	1 11/32	2 1/32	3 3/8	4 1/16
3	7/64	9/16	1 1/8	1 5/8	2 15/32	4 3/32	4 29/32
3 1/2	1/8	5/8	1 9/32	1 29/32	2 27/32	4 3/4	5 11/16
4	9/64	23/32	1 7/16	2 5/32	3 1/4	5 13/32	6 15/32
5	3/16	29/32	1 25/32	2 11/16	4 1/32	6 23/32	8 1/16
6	7/32	1 1/16	2 5/32	3 7/32	4 27/32	8 1/16	9 21/32
8	9/32	1 7/16	2 27/32	4 9/32	6 13/32	10 11/16	12 13/16
10	11/32	1 25/32	3 9/16	5 11/32	8	13 11/32	16
12	7/16	2 1/8	4 1/4	6 3/8	9 9/16	15 31/32	19 5/32
14	1/2	2 7/16	4 7/8	7 5/16	11	18 5/16	22
16	9/16	2 13/16	5 19/32	8 3/8	12 9/16	20 15/16	25 1/8
18	5/8	3 1/8	6 9/32	9 7/16	14 1/8	23 9/16	28 9/32
20	11/16	3 1/2	7	10 15/32	15 23/32	26 3/16	31 13/32
22	3/4	3 27/32	7 11/16	11 17/32	17 9/32	28 13/16	34 9/16
24	27/32	4 3/16	8 3/8	12 9/16	18 27/32	31 13/32	37 11/16
26	29/32	4 17/32	9 3/32	13 5/8	20 13/32	34 1/32	40 27/32
30	1 1/32	5 1/4	10 15/32	15 3/4	23 9/16	39 1/4	47 1/8
34	1 5/32	5 29/32	11 27/32	17 13/16	26 23/32	44 17/32	53 3/8
36	1 7/32	6 1/4	12 17/32	18 7/8	28 7/32	47	56 17/32
42	1 7/16	7 5/16	14 5/8	22	32 31/32	54 31/32	65 15/16

NOM SIZE	INSIDE ARC						
	AA	BB	CC	DD	EE	FF	GG
2	1/32	5/32	5/16	15/32	23/32	1 3/16	1 7/16
2 1/2	3/64	3/16	13/32	19/32	29/32	1 1/2	1 13/16
3	3/64	1/4	1/2	23/32	1 3/32	1 13/16	2 5/32
3 1/2	1/16	9/32	9/16	27/32	1 9/32	2 1/8	2 9/16
4	1/16	5/16	21/32	31/32	1 15/32	2 7/16	2 15/16
5	5/64	13/32	13/16	1 1/4	1 27/32	3 3/32	3 23/32
6	3/32	1/2	1	1 1/2	2 7/32	3 23/32	4 15/32
8	1/8	11/16	1 11/32	2	3 1/32	5 1/32	6 1/32
10	5/32	27/32	1 11/16	2 17/32	3 25/32	6 5/16	7 9/16
12	7/32	1	2 1/32	3 1/16	4 9/16	7 19/32	9 1/8
14	1/4	1 7/32	2 7/16	3 21/32	5 1/2	9 5/32	11
16	9/32	1 13/32	2 13/16	4 3/16	6 9/32	10 15/32	12 5/8
18	5/16	1 9/16	3 1/8	4 23/32	7 1/16	11 25/32	14 1/8
20	11/32	1 3/4	3 1/2	5 1/4	7 27/32	13 3/32	15 11/16
22	3/8	1 29/32	3 27/32	5 3/4	8 5/8	14 3/8	17 9/32
24	13/32	2 3/32	4 3/16	6 9/32	9 7/16	15 11/16	18 27/32
26	15/32	2 9/32	4 17/32	6 13/16	10 7/32	17 1/32	20 13/32
30	17/32	2 5/8	5 1/4	7 7/8	11 25/32	19 5/8	23 9/16
34	19/32	2 31/32	5 29/32	8 29/32	13 3/8	22 9/32	26 11/16
36	5/8	2 13/16	6 1/4	9 7/16	14 1/8	23 5/8	28 1/4
42	23/32	3 21/32	7 5/16	10 19/32	16 1/2	26 3/8	32 31/32

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Print Reading and Layout for Pipe Welding
Unit 2

Assignment Sheet 1—Solve Trigonometry Problems for Unknown Sides

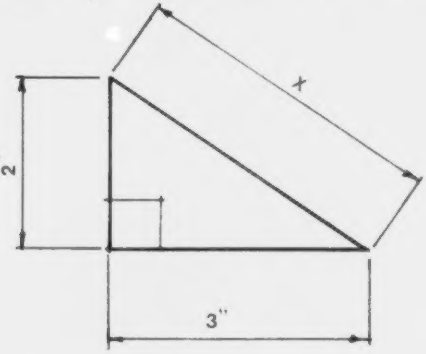
Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Use of correct formula	______
Correct measurements of unknown sides	______

Note: The student may refer to examples in the unit objectives.

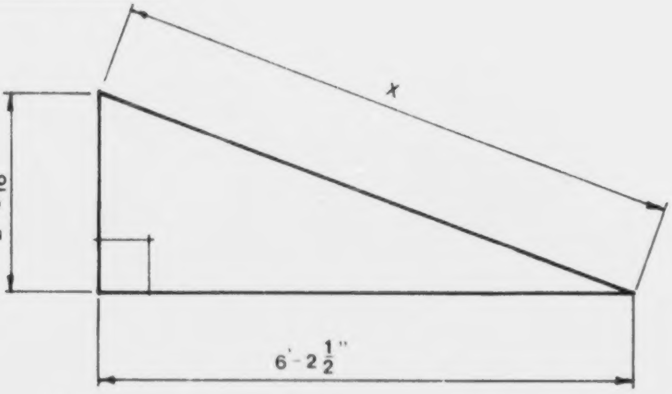
Problems:

a.



x = ____________________

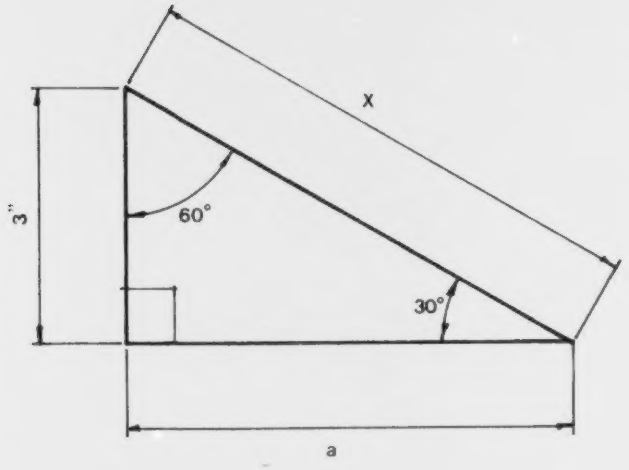
b.



x = ____________________

Assignment Sheet 1

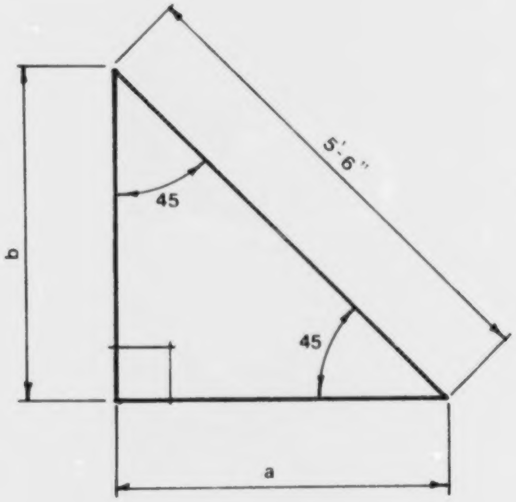
c.



a = ____________________

x = ____________________

d.

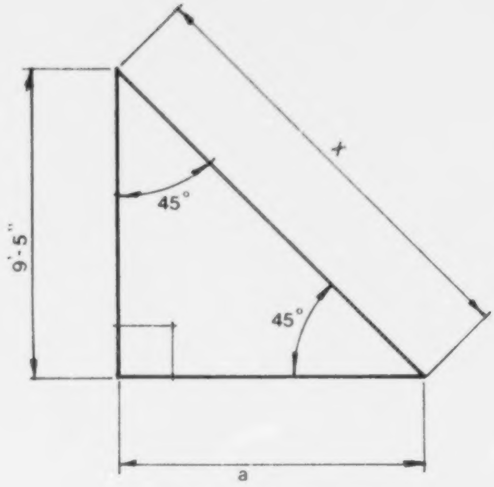


a = ____________________

b = ____________________

Assignment Sheet 1

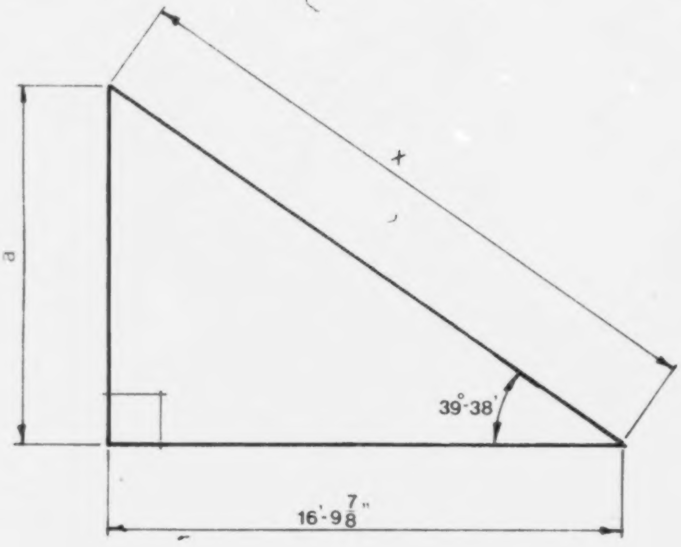
e.



a = ____________________

x = ____________________

f.


x
a
39°-38'
16'-9 7/8"

a = ____________________

x = ____________________

Print Reading and Layout for Pipe Welding
Unit 2

Assignment Sheet 2—Solve Trigonometry Problems for Unknown Angles

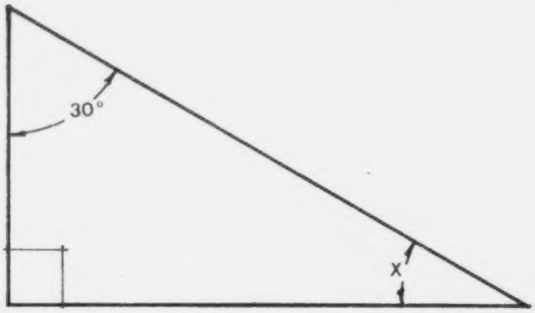
Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Use of correct formula	______
Correct measurements of unknown sides	______

Note: The student may refer to examples in the unit objectives.

Problems:

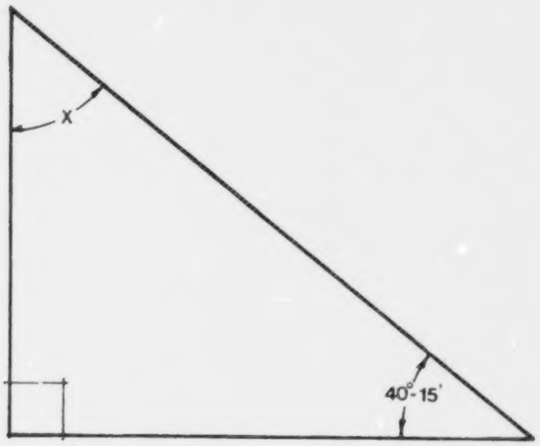
a.



X = ______________

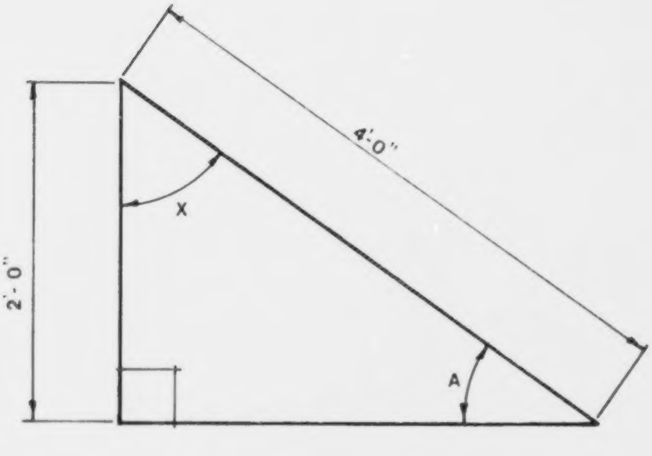
Assignment Sheet 2

b.



X = ____________________

c.

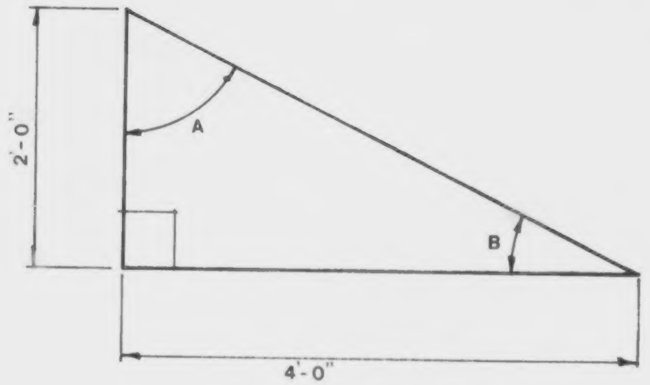


A = ____________________

X = ____________________

Assignment Sheet 2

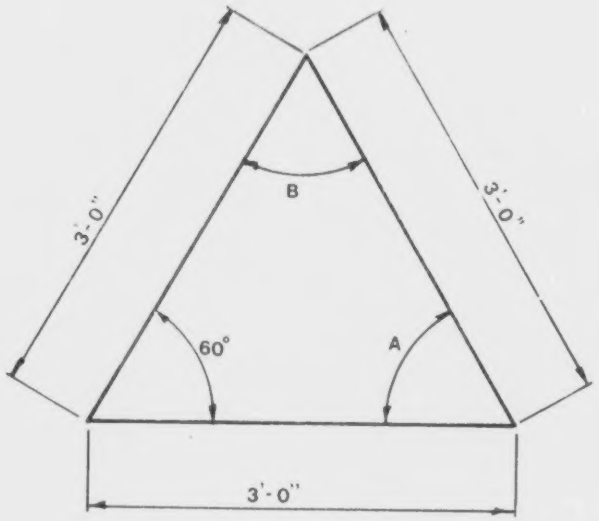
d.



A = ____________________

D = ____________________

e.


3'-0"
B
3'-0"
60°
A
3'-0"

A = ____________________

B = ____________________

Print Reading and Layout for Pipe Welding
Unit 2

Job Sheet 1—Develop a Template for a Two-Piece 90° Turn

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Adjustment of wing dividers	______
Initial drawing	______
Division into equal parts	______
Line development	______
Quality of paste-up template	______

A. Tools and materials

Retractable measuring tape
Framing square
Steel rule
Soapstone marker
Template material as selected by instructor
Pipe as selected by instructor
Drawing pencil
Construction paper, scissors, and scotch tape
Wing dividers

B. Procedures

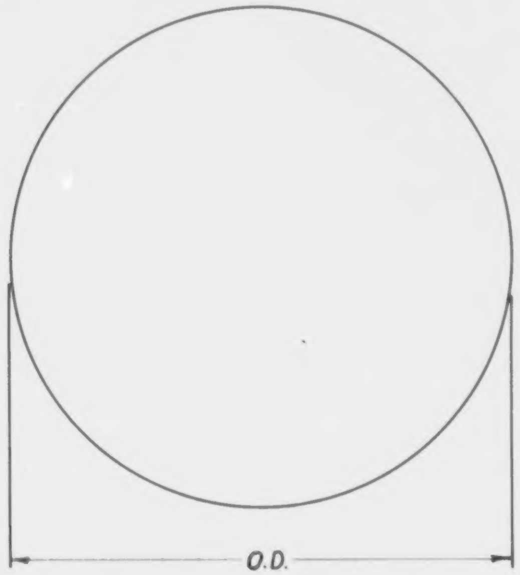
☐ 1. Position the construction paper on a flat working surface with the selected pipe nearby.

☐ 2. Measure the OD of selected pipe.

Job Sheet 1

☐ 3. Adjust wing dividers and draw a circle equal to the diameter of the pipe.

Example:



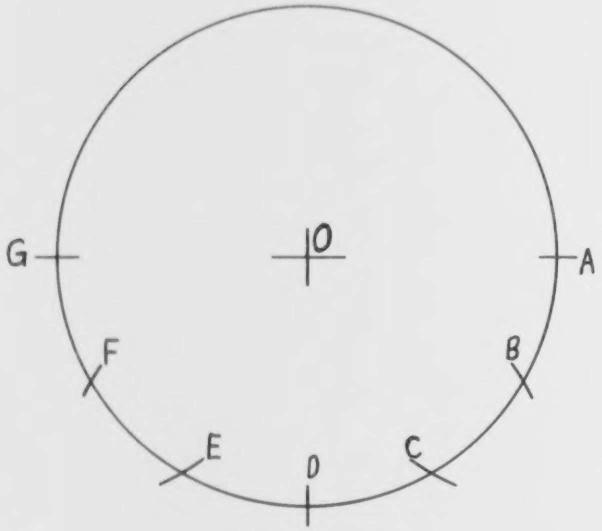
☐ 4. Divide the bottom half of the circle into six equal parts according to the following procedure:

- a. Draw a line through the center to find points G, O, and A.
- b. Use point A as a center and the distance A-O as a radius and swing an arc to create point C.
- c. Use point G as a center and the distance A-O as a radius and swing an arc to create point E.
- d. Bisect the arc of the circle between points E and C to create point D, then connect points D and O with a vertical line.
- e. Use point D as a center and the distance D-O as a radius and swing arcs left and right to create points F and B.

Job Sheet 1

f. Use the distance G-F as a radius and check lower half of circle to make sure the six parts are equal.

Example:



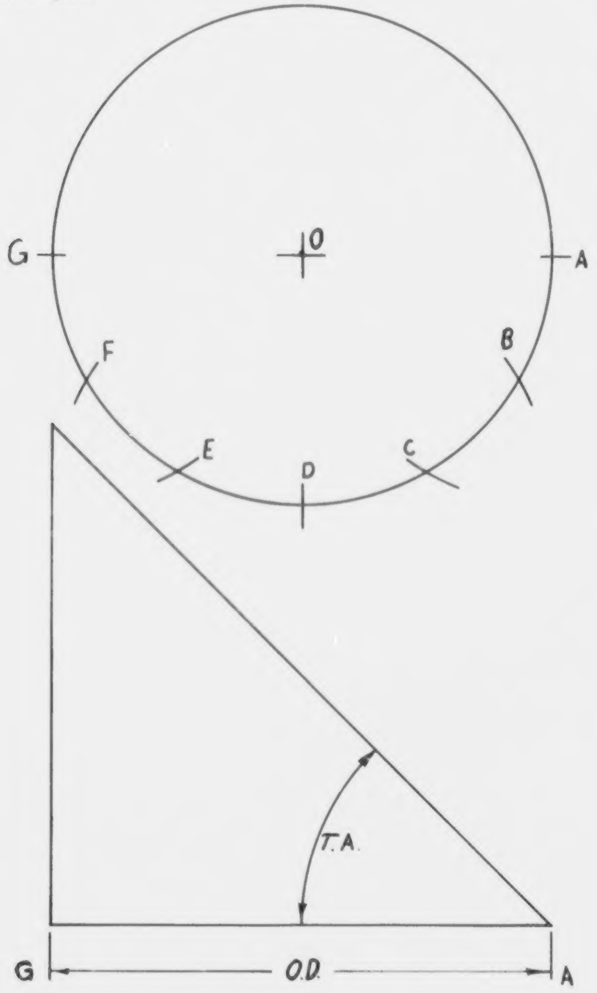
☐ 5. Move to a convenient distance below the circle and draw a horizontal line equal in distance to the OD of the pipe and so that the ends of the GA vertical line are in line with the ends of the GA line across the circle.

Job Sheet 1

☐ 6. Use the vertical line as reference and create a template angle (TA) equal to one-half the required angle for the pipe turn.

Note: Since the required angle is 90°, half that angle would be 45°.

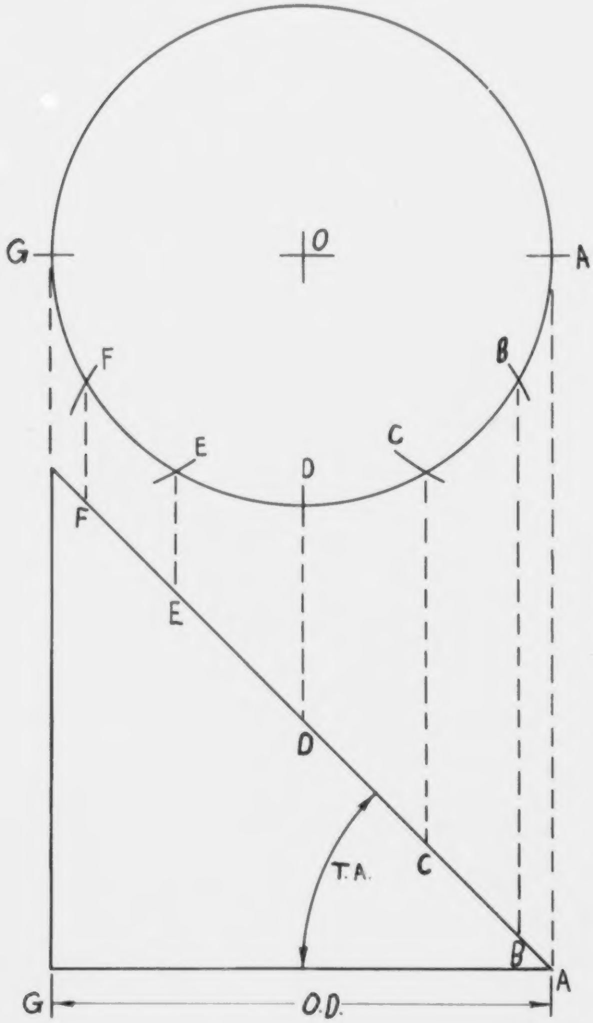
Example:



Job Sheet 1

☐ 7. Draw vertical lines down from all points on the half-circle so that they intersect the TA, then letter points along the TA to correspond with points on the half circle.

Example:



☐ 8. Determine the circumference of the pipe by multiplying the diameter of the pipe by 3.141.

Job Sheet 1

☐ 9. Draw a line to the right of the TA base line so that is equal to the circumference of the pipe (refer to Figure 1 that accompanies this job sheet).

☐ 10. Use the distance GF on the semi-circle as a radius, divide the extension line into 12 equal parts and number them as indicated to reflect points on the semi-circle and along the TA (refer to Figure 1).

☐ 11. Go to each lettered point on the extension line and draw vertical lines up from each point so that they extend beyond point G on the TA (refer to Figure 2).

☐ 12. Draw horizontal lines from each point on the TA so that they intersect with the corresponding vertical lines on the extension line (refer to Figure 2).

☐ 13. Draw lines to connect the intersecting points above the extension lines to complete the curve for the 90° turn (refer to Figure 2).

☐ 14. Cut the pattern out and scotch tape it together to form the 90° turn.

☐ 15. Have your instructor check your work.

Note: At this point, your instructor may direct you to transfer the pattern to template material and use the template to properly mark selected pipe.

☐ 16. Check in tools and materials and clean area.

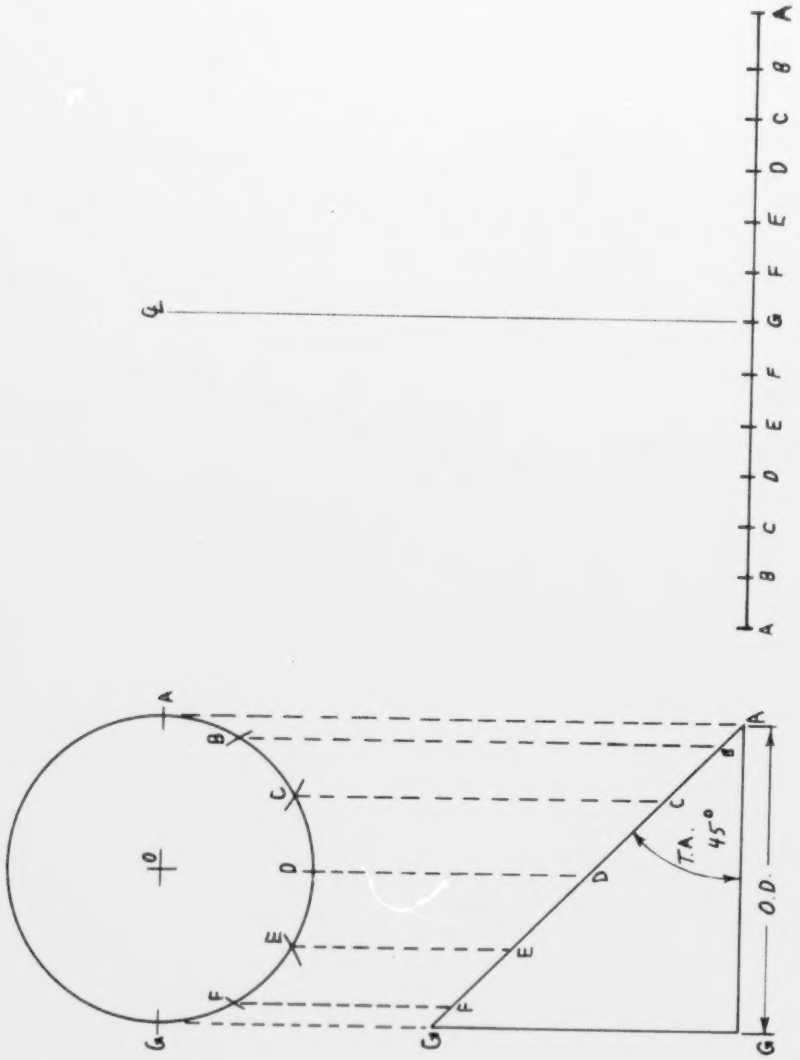
Evaluator's comments: ______________________________

____

____

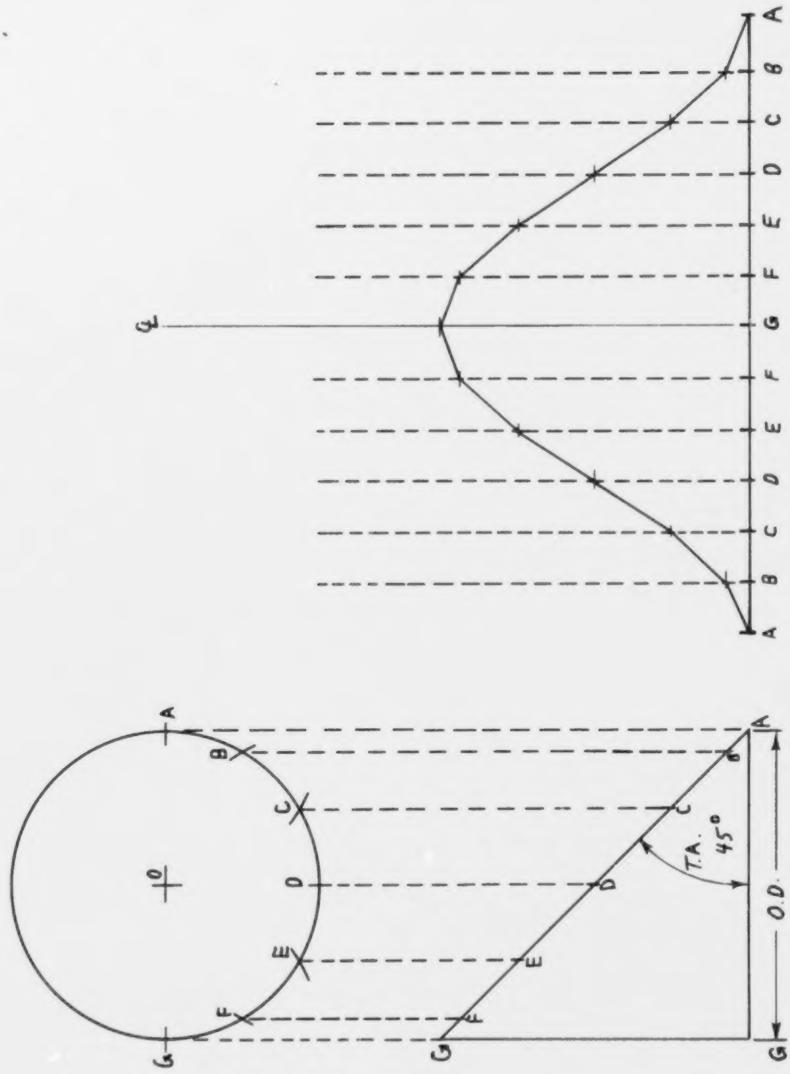
Job Sheet 1

Figure 1


A
B
C
D
E
F
G
F
E
D
C
B
A
℄
O
A
B
C
D
E
F
G
A
B
C
D
E
F
G
T.A.
45°
O.D.
A
G

Job Sheet 1

Figure 2


A
B
C
D
E
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G
F
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C
B
A
℄
O
A
B
C
D
E
F
G
A
B
C
D
E
F
G
T.A.
45°
O.D.
G

Print Reading and Layout for Pipe Welding
Unit 2

Job Sheet 2—Develop a Template for a 90° Branch with Pipes of Equal Size

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Basic measurements and drawings	______
Line development	______
Line transfer	______
Quality of paste-up template	______

A. Tools and materials

Retractable measuring tape
Framing square
Steel rule
Soapstone marker
Template material as selected by instructor
Pipe as selected by instructor
Drawing pencil
Construction paper, scissors, and scotch tape
Wing dividers

B. Procedures

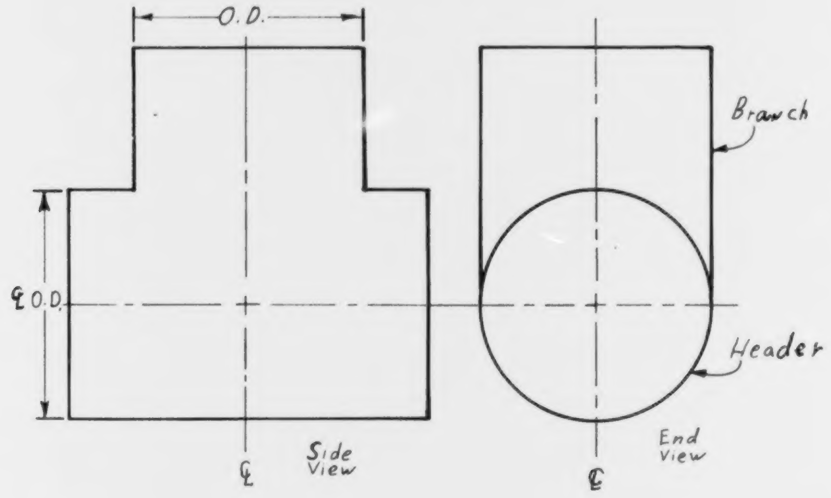
☐ 1. Position the construction paper on a flat working surface with the selected pipe nearby.

☐ 2. Measure the OD of selected pipe.

Job Sheet 2

☐ 3. Use the OD as the reference dimension and lay out a center line long enough that side and end views of the branch can be constructed side by side.

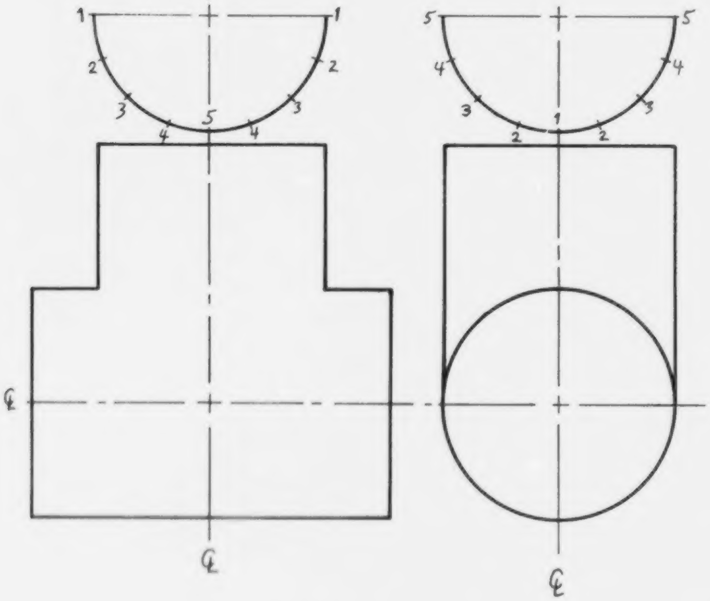
Example:


O.D.
℄ O.D.
℄
Side View
Branch
Header
End View
℄

Job Sheet 2

☐ 4. Draw half circles directly above the end and side views, divide half circles into eight equal parts and number as illustrated.

Example:

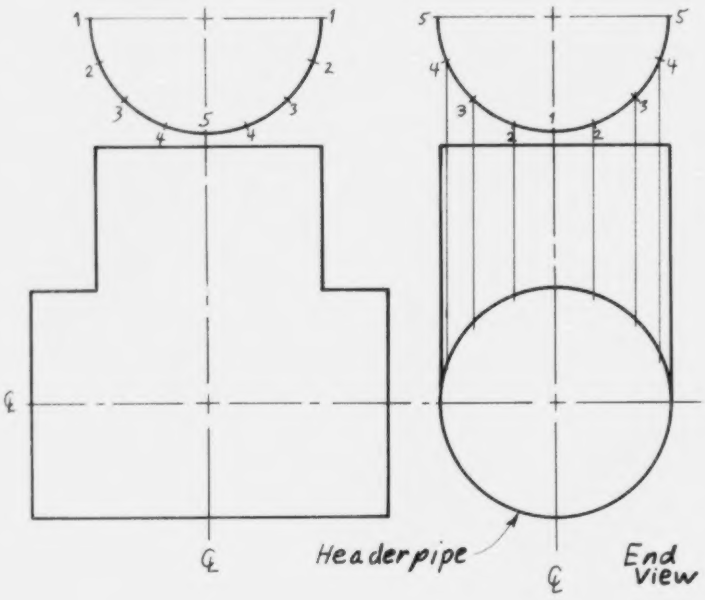


1
2
3
4
5
4
3
2
1
5
4
3
2
1
2
3
4
5
℄
℄
℄

Job Sheet 2

☐ 5. Use a square and draw vertical lines down from each point on the half circle above the header until they intersect points on the circumference of the header pipe.

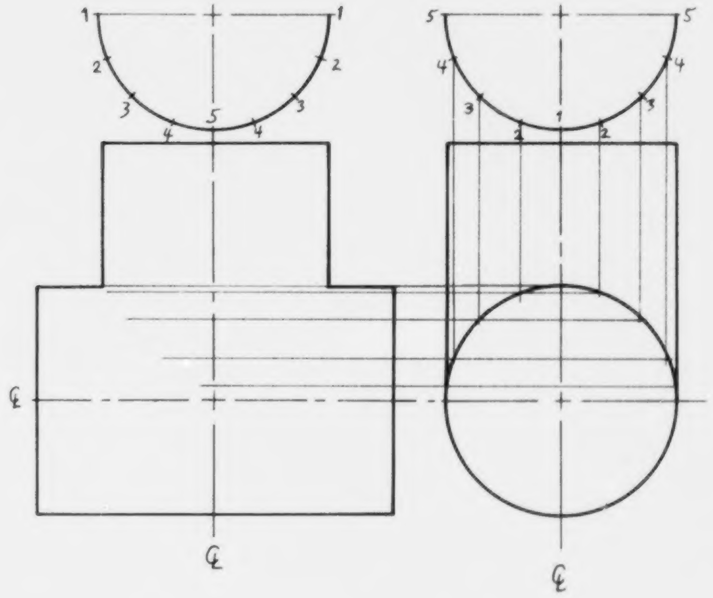
Example:


1
1
2
2
3
3
5
4
4
5
5
4
4
3
3
1
2
2
℄
℄
Headerpipe
℄
End View

Job Sheet 2

☐ 6. Transfer lines from the intersecting points on the circumference of the header to the side view.

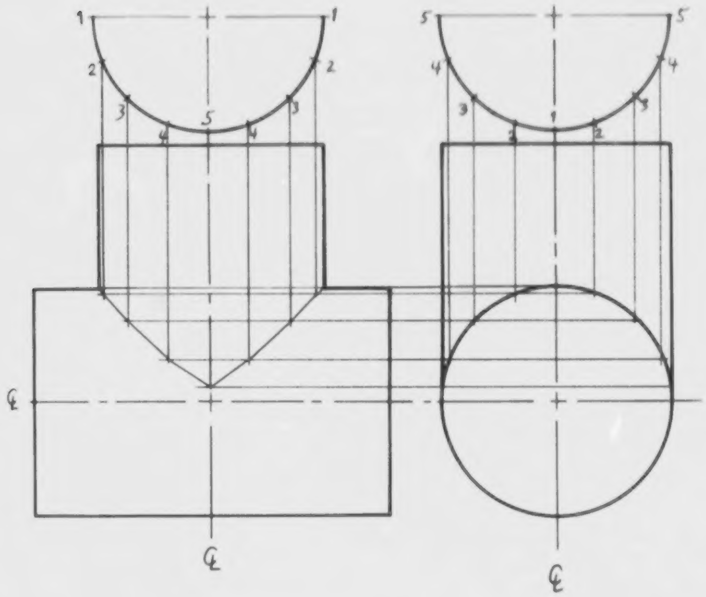
Example:


1
1
2
2
3
3
4
5
4
5
5
4
4
3
3
2
1
2
℄
℄
℄

Job Sheet 2

☐ 7. Use a square and draw vertical lines down from each point on the half circle above the side view until they intersect the lines just transferred from the end view.

Example:



☐ 8. Draw an extension line to the right of the horizontal center line of the end view so that the line is equal to the circumference of the branch connection (refer to Figure 1 that accompanies this job sheet).

☐ 9. Form a rectangle with the extension line as the base so that the sides are equal to the height of the branch connection (refer to Figure 1).

☐ 10. Divide the extension line into 16 equal parts, extend vertical lines to the top of the rectangle and number as indicated (refer to Figure 1).

☐ 11. Transfer the horizontal lines from both the side and end views to the right so that they intersect the vertical lines in the rectangle at numbered points corresponding to the numbered points in the side and end views (refer to Figure 1).

☐ 12. Connect the points of intersection with a line (refer to Figure 1).

Job Sheet 2

☐ 13. Draw directly below the side view a rectangle that is equal in length to the circumference of the header pipe (refer to Figure 2).

☐ 14. Divide the rectangle below the side view into eight equal parts and number as indicated (refer to Figure 2).

☐ 15. Transfer lines from the side view down vertically so that numbers in the side view correspond with numbers in the rectangle below the side view (refer to Figure 2).

☐ 16. Connect the points of intersection with lines on each side of the vertical center line of the rectangle (refer to Figure 2).

☐ 17. Cut out both angular shapes formed in the rectangles, and scotch tape them together to check the accuracy of your layout.

☐ 18. Have your instructor check your work.

Note: At this point, your instructor may direct you to transfer the pattern to template material and use the template to properly lay out selected pipe.

☐ 19. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

____

____

Job Sheet 2

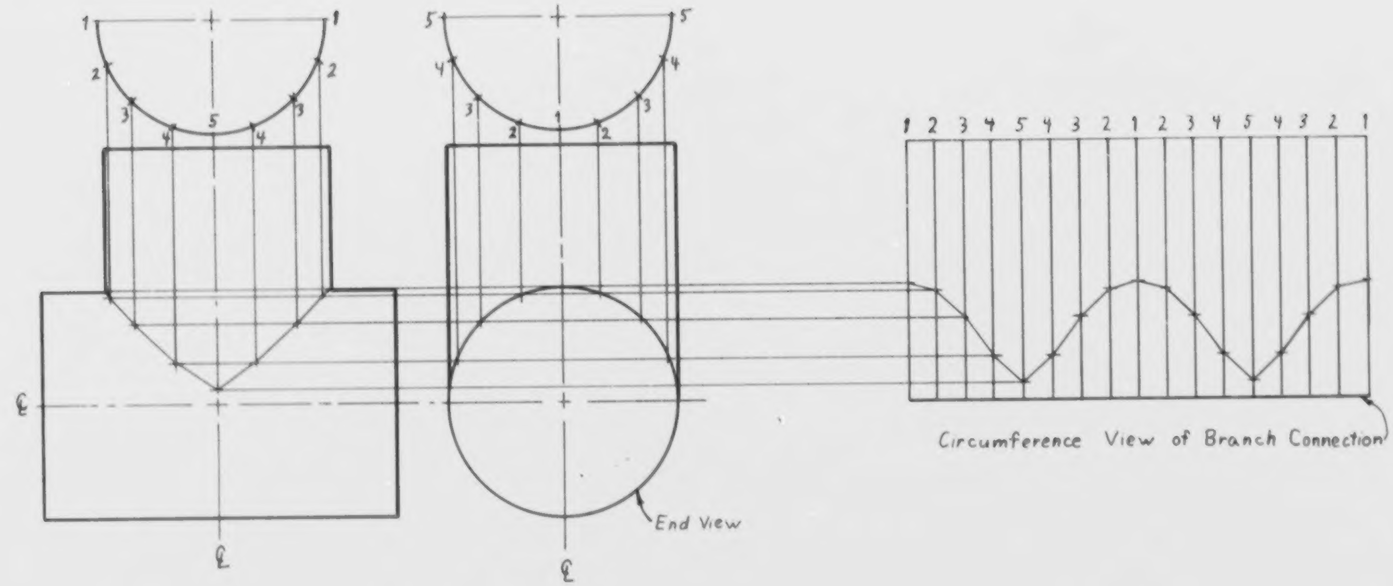
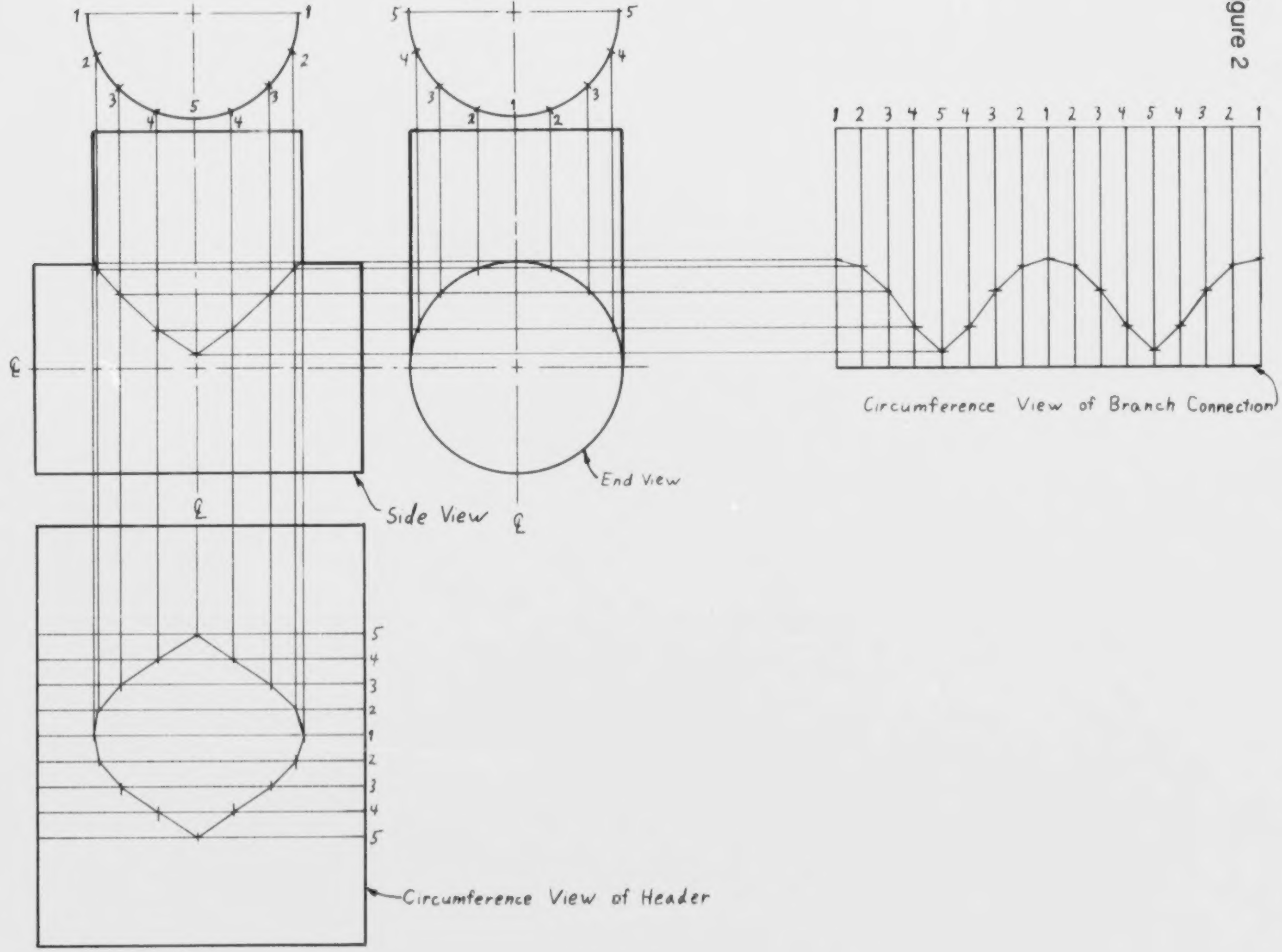

1 2 3 4 5 4 3 2 1
5 4 3 2 1 2 3 4 5
1 2 3 4 5 4 3 2 1 2 3 4 5 4 3 2 1
℄
℄
℄
End View
Circumference View of Branch Connection

Figure 1

Figure 2


1 2 3 4 5 4 3 2 1 2 3 4 5 4 3 2 1
℄
℄
℄
Side View
End View
Circumference View of Branch Connection
Circumference View of Header

Print Reading and Layout for Pipe Welding
Unit 2

Job Sheet 3—Develop a Template for a 45° Branch Connection

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Basic measurements and drawing	______
Stretchout development	______
Quality of paste-up template	______

A. Tools and materials

Retractable measuring tape
Framing square
Steel rule
Soapstone marker
Template material as selected by instructor
Pipe as selected by instructor
Drawing pencil
Construction paper, scissors, and scotch tape
Wing dividers

B. Procedures

☐ 1. Position the construction paper on a flat working surface with the selected pipe nearby.

☐ 2. Measure the OD of selected pipe.

☐ 3. Use the OD as the reference dimension and lay out a rectangle to represent the header with each end equal to the OD (refer to Figure 1 that accompanies this job sheet).

☐ 4. Draw half circles at the left end of the header, divide into six equal parts and number as illustrated (refer to Figure 1).

☐ 5. Project points on the half-circle across the side view of the header (refer to Figure 1).

Job Sheet 3

☐ 6. Draw the stretchout of the branch connection equal to the circumference of the pipe and extend at a 45° angle above the header (refer to Figure 1).

☐ 7. Draw a half circle above branch stretchout, divide into 12 equal parts, and number as indicated (refer to Figure 1).

☐ 8. Extend points on the branch half-circle down at a 45° angle so that they intersect the horizontal line on the header (refer to Figure 1).

☐ 9. Connect intersecting points on the header with a line (refer to Figure 2).

☐ 10. Draw the stretchout for the branch connection to the right of the half-circle on the branch connection so that the stretchout equals the circumference of the pipe (refer to Figure 2).

☐ 11. Make extension lines from header and branch as indicated and divide branch stretchout into 12 equal parts (refer to Figure 2).

☐ 12. Extend lines down across the branch stretchout to intersect lines extended from the header and branch (refer to Figure 2).

☐ 13. Connect intersecting points on the branch stretchout with a line (refer to Figure 2).

☐ 14. Draw the stretchout for the header just below the side view so that the stretchout is equal to the circumference of the header (refer to Figure 3).

☐ 15. Find the center line of the header stretchout, then divide header stretchout into six equal parts with three parts above and three parts below the center line (refer to Figure 3).

☐ 16. Transfer the numbered points on the side view down to the header stretchout so that they intersect corresponding points on the stretchout (refer to Figure 3).

☐ 17. Connect the points of intersection on the header stretchout with a line (refer to Figure 3).

☐ 18. Cut out header and branch stretchouts, and scotch tape them together to check the accuracy of your layout.

☐ 19. Have your instructor check your work.

Note: At this point, your instructor may direct you to transfer the pattern to template material and use the template to properly lay out selected pipe.

Job Sheet 3

☐ 20. Check in tools and materials and clean area.

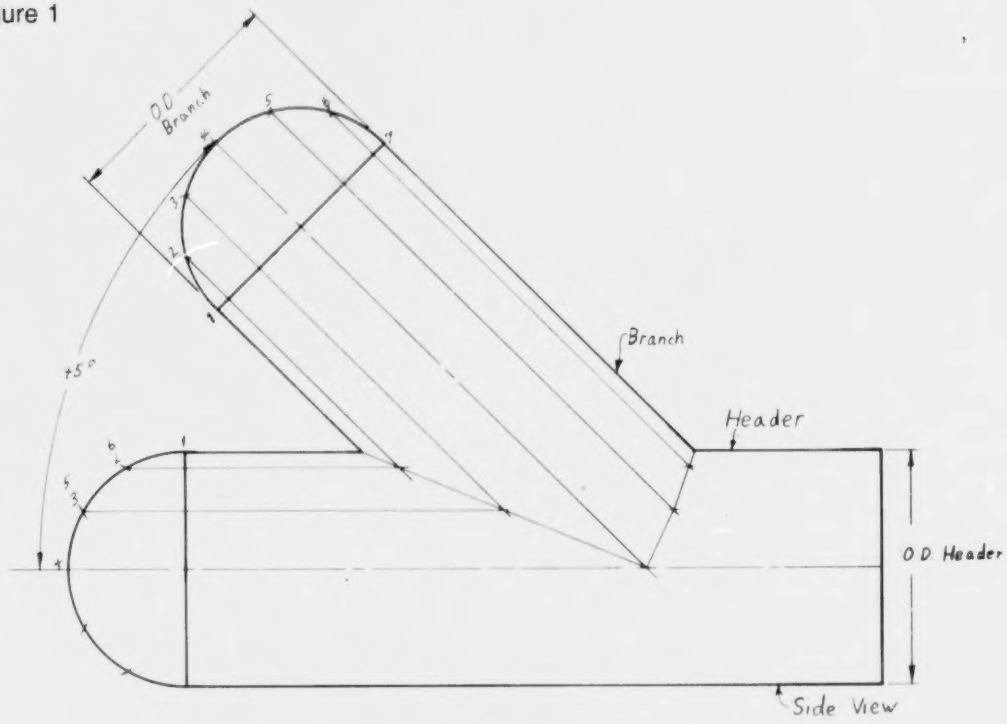
Evaluator's comments: ______________________________

____

____

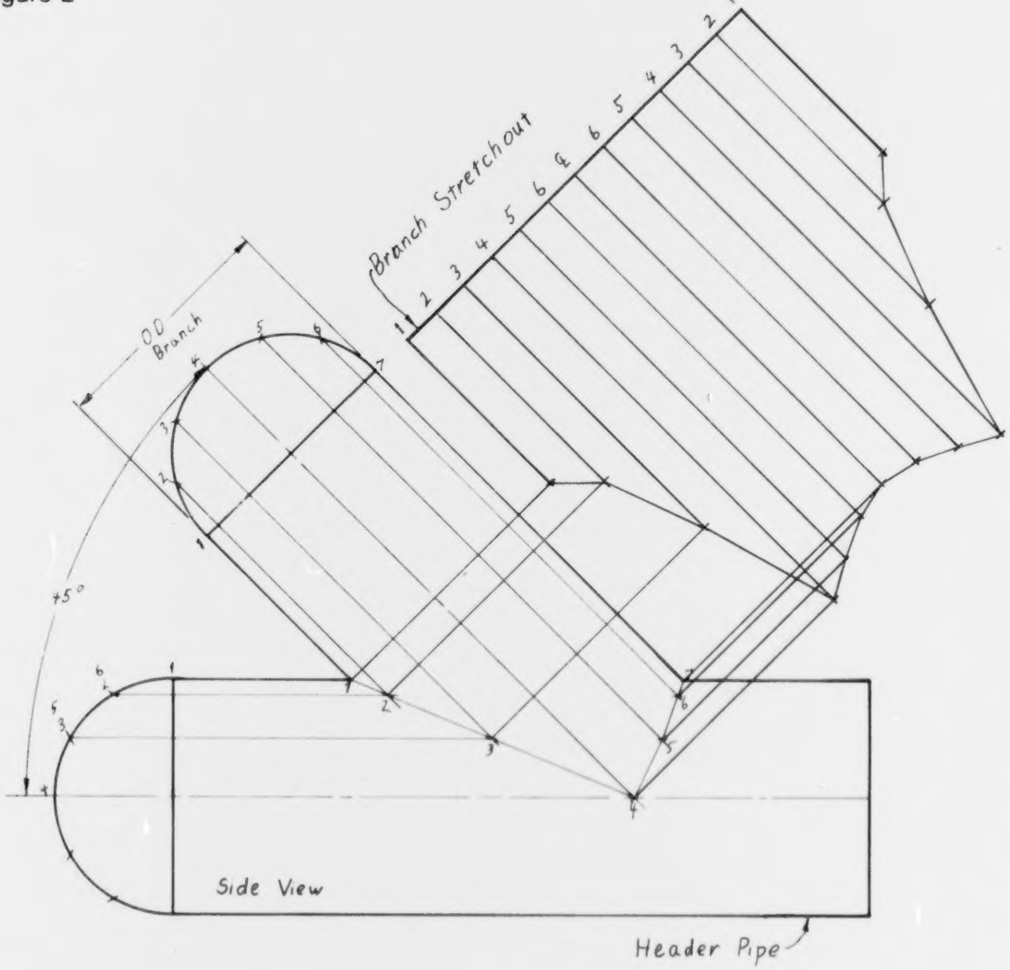
Job Sheet 3

Figure 1


O.D. Branch
4
5
6
7
3
2
1
Branch
Header
45°
6
5
3
1
4
O.D. Header
Side View

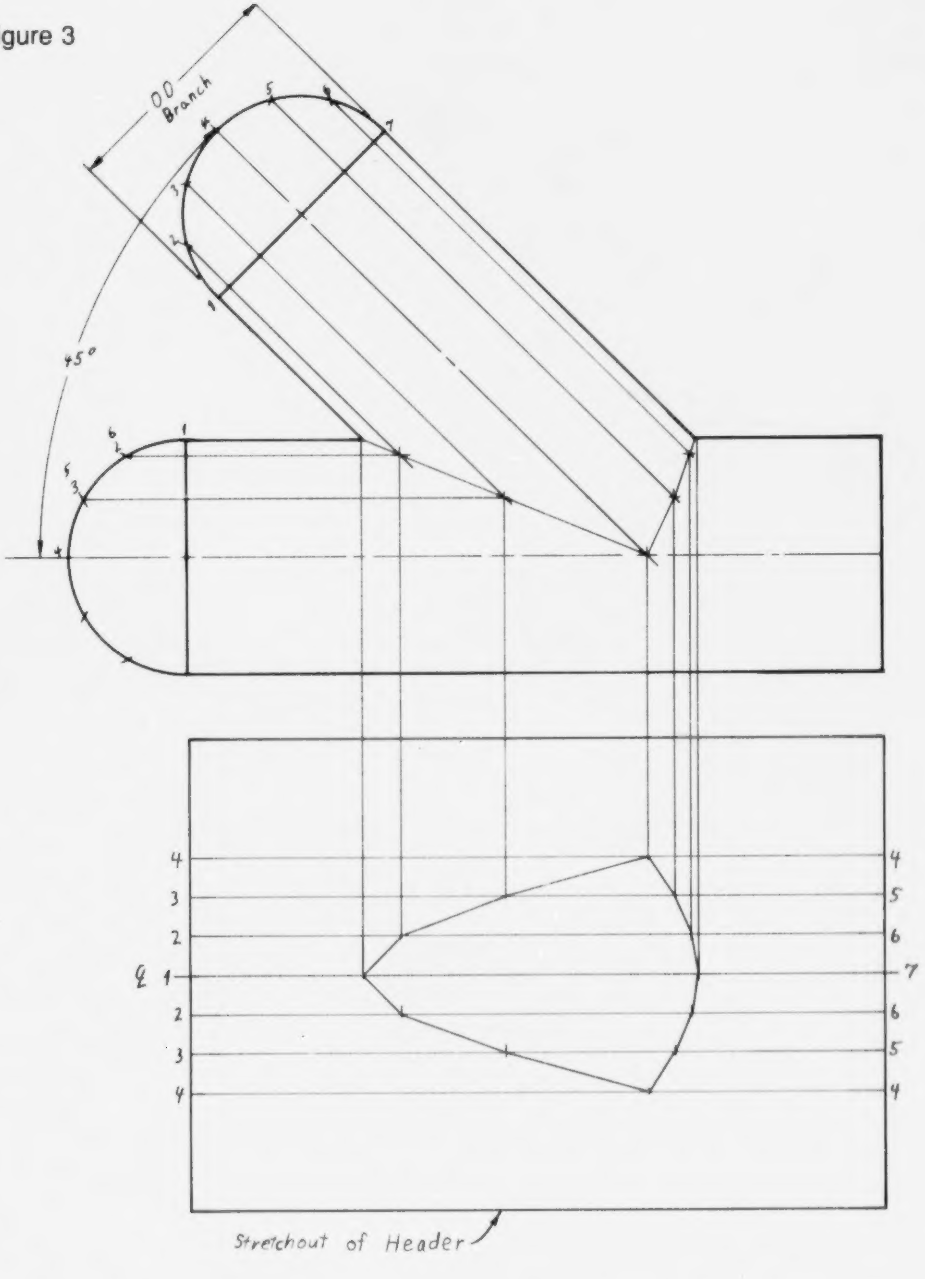
Job Sheet 3

Figure 2


Branch Stretchout
1
2
3
4
5
6
℄
6
5
4
3
2
1
O.D. Branch
45°
Side View
Header Pipe

Job Sheet 3

Figure 3


OD Branch
5
6
7
4
3
2
1
45°
6
5
3
1
4
4
3
2
℄ 1
2
3
4
4
5
6
7
6
5
4
Stretchout of Header

Pipe Welding Techniques and Applications

Unit 3

Objective Sheet

Unit Objective

After completing this unit, the student should be able to bevel and prepare pipe for welding, weld to specifications V-groove butt joints in the horizontal; vertical up; vertical up, 45° inclined; vertical down; and vertical down, 45° inclined positions. The student should also be able to conduct face-bend, root-bend, side-bend, and nick-break tests on completed pipe welds. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to pipe welding techniques and applications with their correct definitions.
2. Select true statements about guidelines for beginning pipe welders.
3. Solve problems about AWS classifications for mild steel and alloy electrodes.
4. Complete statements about electrode selection for pipe welding.
5. Complete statements about joint preparation, fit-up, and alignment.
6. Select true statements about guidelines for joint dimensioning.
7. Complete statements about guidelines for joint preparation.
8. Identify common methods of pipe alignment.
9. Match common problems in pipe welding with their causes.
10. Complete a pipe welding troubleshooting chart.
11. Complete statements about ways to prevent pipe welds from cracking.
12. Solve problems about the concept of quartering.

Objective Sheet

13. Select true statements about performance qualification for pipe welding.

14. Complete statements about qualification testing and its importance in pipe welding.

15. Select true statements about methods of pipe inspection.

16. Identify specimen locations for AWS welding procedure qualification.

17. Select true statements about AWS specifications for specimen preparation.

18. Select true statements about API procedure qualification.

19. Identify specimen locations for AWS welder qualification.

20. Bevel and prepare pipe for welding. (Job Sheet 1)

21. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the horizontal position. (Job Sheet 2)

22. Conduct root- and face-bend tests and a nick-break test on welded pipe. (Job Sheet 3)

23. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up position. (Job Sheet 4)

24. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical up, 45° inclined position. (Job Sheet 5)

25. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down position. (Job Sheet 6)

26. Weld to specifications a V-groove butt joint on 6″ schedule 40 pipe in the vertical down, 45° inclined position. (Job Sheet 7)

Welding Techniques and Applications
Unit 3

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions section that follows. Plan for classroom activities.

3. Plan for enrichment of exceptional students as well as accommodation of special needs students.

4. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss the job sheets. Review criteria for evaluation of these activities.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

12. Make copies of the written test. Add or modify test items as needed.

13. Give written test.

14. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

15. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Arrange for all the alignment tools needed to properly demonstrate Objective 8. Invite a local or area pipe welder to help demonstrate to students how common carpentry tools can be used to assure good pipe fit-up and alignment. Skill area: **learning to learn**.

2. When presenting Objective 12 about the concept of quartering, emphasize the importance of quartering for controlling heat input and distortion. Distortion is a common problem with beginning pipe welders, and the job sheets in this unit use the quartering concept to help make early pipe welding attempts easier and better. Skill area: **learning to learn**.

3. Prepare specimens to reinforce the information in Objectives 13 through 18. Show students how to locate exactly where specimens should be taken from, and how to prepare specimens for various bend tests. If you have the equipment, demonstrate a tensile test. Skill area: **learning to learn**.

4. Use Teacher Supplement 1 to reinforce Objective 19. Show students the AWS form, Contractor's Welder Qualification Tests Record, and impress upon students the variety of information that is required for such a test. Skill area: **learning to learn**.

5. Invite the owner/operator of a local or area pipe welding facility to talk to the class about pipe welding opportunities in your state or region. Ask the speaker to talk about the kind of experience it takes to become a good pipe welder. Skill area: **personal and career development**.

Resources Used in Developing This Unit

1. *New Lessons in Arc Welding*. Cleveland, OH: The Lincoln Electric Company, 1981.

2. *The Procedure Handbook of Arc Welding, Twelfth Edition*. Cleveland, OH: The Lincoln Electric Company, 1981.

3. *Standard for Welding Pipelines and Related Facilities, API STD 1104*. Washington, DC: American Petroleum Institute, 1977.

4. *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing, AWS D10, 9-80*. Miami, FL: American Welding Society, 1981.

Suggested Activities

Suggested Supplemental Resources

1. "SMAW Pipe Uphill," contains 19 topics, and HOB-4, "SMAW Pipe Downhill," contains 11 topics. both available in ½" VHS and other formats. Available from:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373
   Phone: 513-332-5217

2. MEC-33, "Shielded Metal Arc Pipe Welding, Downhill," and MEC-34, "Shielded Metal Arc Pipe Welding, Uphill," are available as filmstrips with cassettes or other formats. Available from:

   Meridian Education Corporation
   Library Filmstrip Center
   236 East Front Street
   Bloomington, IL 61701
   Phone: 309-827-5455

3. VTR-4, "Pipe Welding," is available in a series of five videotapes and texts. Available from:

   Video Training Resource, Inc.
   7500 West 78th Street
   Edina, NM 55435-2889
   Phone: 800-828-8190 or 612-944-8190

4. Weld #38031 is available in VHS format or ¾" tape. This production details a single weld made on the Alaska pipeline. Available from:

   Alyeska Pipeline Service Co.
   1901 South Bragaw MS 581
   Anchorage, AK 99512
   Phone: 907-265-8871

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Suggested Activities

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Pipe Welding Techniques and Applications
Unit 3

Answers to Written Test

1. a. 4
   b. 7
   c. 12
   d. 9
   e. 1
   f. 8
   g. 3
   h. 10
   i. 5
   j. 13
   k. 2
   l. 11
   m. 6

2. a, b, d, e

3. a. An arc-welding electrode
   b. All positions
   c. Diameter in fractions of an inch

4. a. Operating
   b. Inside
   c. Thin
   d. Pinholes
   e. EXX10, EXX18
   f. Alloy
   g. X-ray quality

5. a. Fit-up
   b. Grind
   c. Hammering
   d. Compensate for this problem
   e. Unsafe

6. b, c, e

7. a. Poor penetration
   b. File
   c. Power brush

8. a. 4
   b. 2
   c. 5
   d. 6
   e. 3
   f. 7
   g. 1

9. a. 3
   b. 5
   c. 2
   d. 4
   e. 1
   f. 8
   g. 7
   h. 10
   i. 6
   j. 9

Answers to Written Test

10. a. Porosity
    b. Slag inclusion
    c. Incomplete fusion
    d. Undercutting

11. a. Small
    b. Stringer bead
    c. Five
    d. 40°F
    e. Do not
    f. Low-hydrogen
    g. Thoroughly
    h. Grind

12. a. 3
    b. 1

13. a, b

14. a. Destructive
    b. A specific application
    c. Selected areas
    d. Welder
    e. Both procedure and welder
    f. Discontinuities

15. b

16. a. 120
    b. 40

17. a, b, c, e

18. a, c

19. a. 4
    b. 2
    c. 1
    d. 3

Pipe Welding Techniques and Applications
Unit 3

Written Test

Name ________________________________ Score ______________

1. Match the terms on the right with their correct definitions.

_____a. An organization that sets standards for transmission line pipe, joint design, fit-up, welding, and inspection

_____b. AWS specifications for qualification of welding procedures and welders at a level that applies to nuclear, chemical, and other systems where a high degree of weld quality is required

_____c. AWS specifications for qualification of welding procedures and welders at a level that applies to low-pressure heating, air conditioning, and other systems where an average degree of weld quality is required

_____d. An organization that sets standards for the design, construction, and welding of boilers and other high-pressure vessels

_____e. A selected area cut from a weld and the adjacent base metal for use in testing the quality of a weld

_____f. The final pass or passes that rise slightly above the outside surface of a pipe weld

_____g. Welds that are deposited between the hot pass and the cover pass, and vary in number depending on pipe thickness

_____h. A situation where one of two pipes in a joint is higher or lower than the pipe to which it is welded

1. Coupon
2. Root face
3. Fill passes
4. API
5. Hot pass
6. Root opening
7. AR 1
8. Cover or cap pass
9. ASME
10. High-low condition
11. Root pass
12. AR 3
13. Nipple

Written Test

______i. The second pass in a pipe welding procedure

______j. A short length of pipe used for training or for qualifying pipe welders

______k. The squared off portion at the base of a pipe nipple

______l. The first pass applied in a pipe weld; it is made without appreciable weaving motion and sometimes called a stringer bead

______m. The separation at the base of pipe nipples when they are aligned with each other

2. Select true statements about guidelines for beginning pipe welders. Place an "X" beside each true statement.

______a. Follow all safety rules regarding proper clothing and handling electrical equipment.

______b. Develop the good habit of handling all pipe with care because even a short piece of pipe can seriously injure a foot if it is carelessly dropped.

______c. When hand-cutting or machine-cutting bevels, make them as neat and clean as possible, even though proper joint preparation is not one of the most important parts of pipe welding.

______d. Develop the good habit of carefully cleaning all passes before finishing a pipe weld, and remember that visually inspecting every pass is a requirement.

______e. Practice the pipe welding test positions and concentrate your learning activities on the procedures that will produce quality welds that will pass both nondestructive and destructive testing.

Written Test

3. Solve problems about AWS electrodes classifications for mild steel and alloy electrodes. Write a brief answer to each of the following problems.

    a. Problem: In an E60XX electrode classification, what does the "E" mean?

    ____

    b. Problem: In an EXX1X electrode classification, what does the "1" mean?

    ____

    c. Problem: What standard is used to classify electrodes by size?

    ____

4. Complete statements about electrode selection for pipe welding. Circle the material that best completes each of the following statements.

    a. The EXX10 class electrodes are usually used for vertical-down cross-country pipe welding because of their special (**operating**) (**outdoor**) characteristics.

    b. EXX10 electrodes produce a steady, concentrated arc which leaves a continuous bead (**inside**) (**outside**) the pipe when the root pass is made.

    c. Because they produce a (**thin**) (**thick**) slag covering, the EXX10 electrodes give good wetting to the sides of the groove, but do not run into the crater and interfere with the arc.

    d. When used properly, EXX10 electrodes produce minimum (**pinholes**) (**cratering**).

    e. For vertical up pipe welding, (**EXX10**) (**EXX18**) electrodes are normally used for the root pass, and (**EXX18**) (**EXX10**) electrodes are used for all other passes.

    f. Certain (**alloy**) (**carbon steel**) pipes require low-alloy, low-hydrogen electrodes.

    g. For (**x-ray quality**) (**stainless steel**) welds, low-hydrogen electrodes such as E7018, E9018, and others are frequently specified to meet standards for high pressure, high strength applications.

Written Test

5. Complete statements about guidelines for joint preparation, fit-up, and alignment. Circle the material that best completes each of the following statements.

   a. Since joint preparation is critical to (**joint design**) (**fit-up**), cut bevels to required angles, remove all slag, and grind the bevels free of imperfections.

   b. (**Grind**) (**Cut**) root faces or lands to specified width with no irregular contours.

   c. For proper fit-up, align pipes or fittings to common centering or reference points without the need for (**hammering**) (**measuring**).

   d. Make joint preparation as exact as possible to avoid putting an extra burden on a welder who must spend extra time to (**compensate for this problem**) (**redo the joint**).

   e. Make joint preparation as exact as possible to avoid a piping system that may not function or subject the installation to (**substandard**) (**unsafe**) performance.

6. Select true statements about guidelines for joint dimensioning. Place an "X" beside each true statement.

   ______a. A joint without a root face should be prepared with a maximum 37.5° angle.

   ______b. Joints without root faces should be separated a distance no more than half the thickness of the pipe.

   ______c. Joints without root faces should use a backup ring or strip with a thickness equal to ⅓ the thickness of the pipe and a length equal to about 1¼ times the pipe thickness.

   ______d. A joint with a root face should be prepared with a maximum 30° angle, and the root face itself should be ⅓ the thickness of the pipe but no more than ⅛".

   ______e. Joints with root faces should be separated a distance no more than half the thickness of the pipe.

7. Complete statements about guidelines for joint preparation. Circle the material that best completes each of the following statements.

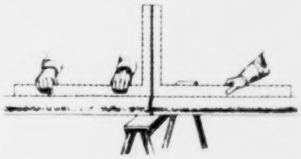
   a. Use a portable grinder to prepare a root face, and remember that a root face too thin will contribute to burn-through, and a root face too thick may contribute to (**poor penetration**) (**undercutting**).

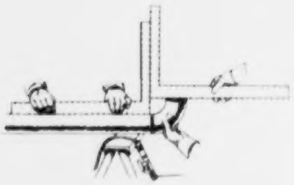
   b. After beveling with the oxyfuel cutting process, remove any remaining slag with a (**file**) (**grinder**).

   c. Use a (**power brush**) (**portable grinder**) to remove scale from the groove surface, and to remove rust and/or contaminants ½" from the outer edge of grooves.

Written Test

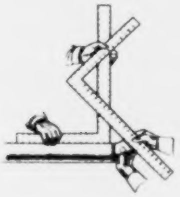
8. Identify common methods of pipe alignment. Place the number of the method below the proper illustration.

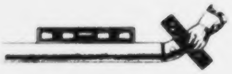




a. ____________________

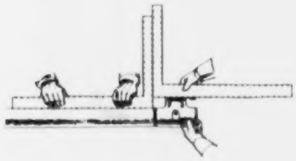
b. ____________________

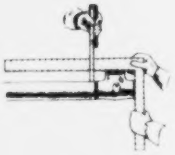




c. ____________________

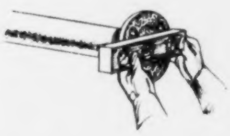
d. ____________________





e. ____________________

f. ____________________



g. ____________________

1. Flange to pipe
2. 90° elbow to pipe
3. Tee to pipe
4. Pipe to pipe
5. 45° elbow to pipe
6. 45° elbow to pipe using levels
7. Tee to pipe with square and rule

Written Test

9. Match common problems in pipe welding with their causes. Place the number of the problem in the blank that describes the cause.

______a. Failure to completely fill the weld root with weld metal

______b. Failure to completely fill the weld root with weld metal because of pipe misalignment

______c. A condition which causes the center of the root bead to have a surface that is below the inside surface of the pipe

______d. Incomplete tie-in at the root or top of the joint between the weld metal and the pipe surfaces

______e. A lack of fusion between two adjacent weld beads or between a weld bead and the adjacent pipe surface

______f. Occurs when excessive penetration causes the weld puddle to blow into the pipe

______g. Occurs when nonmetallic solids from the flux are trapped in the weld metal or between the weld metal and the pipe, and long slag inclusions are called wagon tracks because they run along the undercut sides of a stringer pass

______h. Gas pockets or voids that occur in the weld metal or on the surface

______i. A groove melted into the base metal adjacent to the weld toe or weld root, and left unfilled by weld metal

______j. Hot cracking indicates problems with filler metals or the welding procedure, and cold cracking indicates problems with filler metals or problems in the base metals of the pipe

1. Cold lap
2. Internal concavity
3. Inadequate penetration
4. Incomplete fusion
5. Inadequate penetration due to high-low
6. Undercutting
7. Slag inclusion
8. Burn-through
9. Cracks
10. Porosity

Written Test

10. Complete the following pipe welding troubleshooting chart. Write the name of the problem in the proper blank.

Problem	Probable Cause	Corrective Procedures
a. ________________	Chemical reactions that take place during welding, too long an arc, wind, or atmospheric conditions	Check for proper amperage Reduce arc length Check dryness of electrode
b. ________________	Rapidly solidifying slag, nonmetallic elements from flux, too low welding current, and improper cleaning	Check for proper amperage Check welding technique Correct contours by grinding Check joint preparation and fit-up
c. ________________	Failure to raise base or metal to melting point, and oxides from improper fluxing	Check joint preparation and fit-up Check root gap and root face Use smaller electrode Use high welding current Slow travel speed
d. ________________	High amperage and long arc, incorrect electrode position, wrong travel speed, and bad welding technique	Reduce amperage and arc length Correct electrode angle Adjust travel speed Remove by grinding

11. Complete statements about ways to prevent pipe welds from cracking. Circle the material that best completes each of the following statements.

a. Make the stringer bead as (**small**) (**large**) as possible and practical.

b. Leave line-up clamps on pipe until (**stringer bead**) (**filler pass**) is completed.

c. Make the hot pass as soon after the stringer bead as possible, within (**five**) (**ten**) minutes.

d. When temperature is below (**50°F**) (**40°F**), preheat the pipe according to wall thickness or manufacturers specifications.

e. (**Do not**) (**Do**) start or end passes at the same point as the pass underneath.

f. Use (**low-hydrogen**) (**EXX10**) electrodes.

g. Clean each pass (**thoroughly**) (**only as needed**).

h. (**Brush**) (**Grind**) stops and starts of each electrode prior to restart.

Written Test

12. Solve problems about the concept of quartering. Circle the number of the item that best solves each of the following problems.

    a. You've been asked to explain to a beginning pipe welder the importance of moving in sequence during a pipe welding procedure. You should:

        (1) Talk about quartering because moving from one quarter of a pipe to an opposite quarter of a pipe helps maintain proper alignment.

        (2) Talk about quartering because moving from one quarter of a pipe to an opposite quarter of a pipe is specifically designed to control distortion.

        (3) Talk about quartering because moving from one quarter of a pipe to an opposite quarter of a pipe helps maintain alignment, controls heat transfer, and helps reduce distortion.

    b. A beginning welder wants to know how to use quartering properly. You should:

        (1) Remind the welder that quartering positions are stated as they are related to the numbers on the face of a clock.

        (2) Remind the welder that quartering positions are stated as they are related to the number of degrees in a circle.

        (3) Remind the welder that quartering positions are just for reference and that actual welding may require a different procedure.

13. Select true statements about performance qualification for pipe welding. Place an "X" beside each true statement.

______a. A qualification test is conducted with two pipe nipples joined by a procedure specified for preparation, fit-up, and welding.

______b. Specifications for a qualification test include every step of the welding procedure including such highly detailed items such as characteristics of the oxyfuel flame and travel speed in inches per minute for each pass.

______c. Records of a qualification test are maintained for three years.

Written Test

14. Complete statements about qualification testing and its importance in pipe welding. Circle the material that best completes each of the following statements.

    a. Procedure qualification testing is a process of using (**nondestructive**) (**destructive**) tests to qualify a welding procedure for a specific manufacturer to make sure the procedure produces the required results.

    b. Welder qualification testing is a process used to qualify welders to make sure they are skilled enough to make the types of welds required for (**a specific application**) (**all types of welding**).

    c. Destructive testing is accomplished by using test specimens or coupons cut from (**selected areas**) (**the side area**) of a weld.

    d. Nondestructive testing may be used as an alternate method to qualify (**welder**) (**procedure**) performance.

    e. Testing for (**procedure**) (**both procedure and welder**) qualification is documented so that problems can be pin-pointed and corrected.

    f. Procedure qualification tests document many variables ranging from electrode size to weather conditions; (**discontinuities**) (**pin-holes**) are carefully recorded and sometimes sketched for clarification.

15. Select true statements about methods of pipe inspection. Place an "X" beside each true statement.

    Note: For a statement to be true, all parts of the statement must be true.

    ______a. Nondestructive testing includes visual inspection or radiographic testing only.

    ______b. Destructive testing includes:

    (1) Tensile test

    (2) Nick-break test

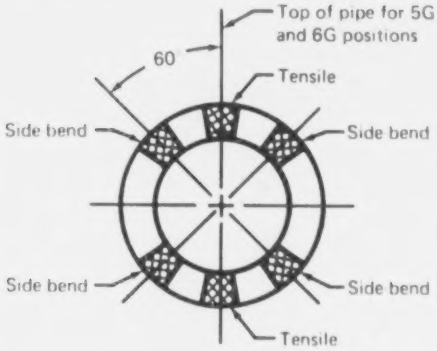
    (3) Root-bend test

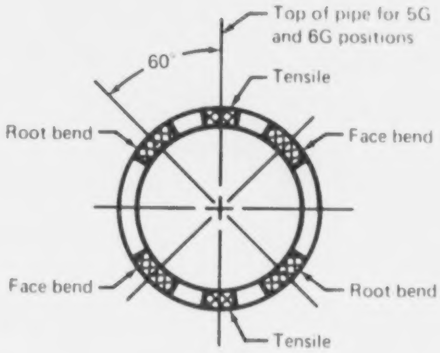
    (4) Face-bend test

    (5) Side-bend test

Written Test

16. Identify specimen locations for AWS welding procedure qualification. In the following illustrations, identify schedule 40 specimen locations with a "40" and schedule 120 locations with a "120".


Top of pipe for 5G and 6G positions
60
Tensile
Side bend
Side bend
Side bend
Side bend
Tensile


Top of pipe for 5G and 6G positions
60°
Tensile
Root bend
Face bend
Face bend
Root bend
Tensile

a. ______________________ b. ______________________

17. Select true statements about AWS specifications for specimen preparation. Place an "X" beside each true statement.

______a. A specimen must not only be cut from a specified place on a test pipe, the specimen must be prepared according to the nature of the test to which it will be subjected.

______b. A tensile test specimen will literally be pulled apart and requires careful preparation with respect to dimensions, machining, and milling.

______c. Root-bend, face-bend, and side-bend specimens require specimens approximately 6″ long with special radius requirements on the corners and limitations on materials removed by machining.

______d. After root-bend, face-bend, and side-bend specimens are properly prepared, they should be tested in a guided-bend jig or with a tensile tester.

______e. Both guided-bend and wraparound testers are available from manufacturers, but in all cases, they need to comply with specifications and be used for specific specimen thicknesses.

Written Test

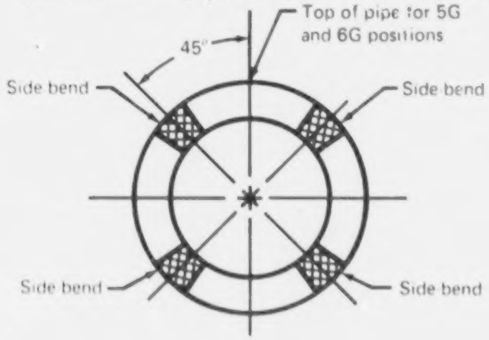
18. Select true statements about API procedure qualification. Place an "X" beside each true statement.

______a. Because API specifications are for pipeline welding, their procedure qualification differs from specifications for industrial welding.

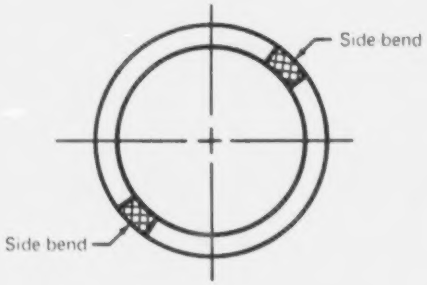
______b. In particular, tensile sections for API testing are taken from positions at approximately two o'clock and eight o'clock.

______c. API specifications also call for a nick-break test which requires special preparation.

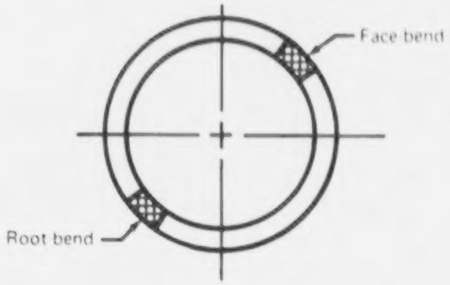
19. Identify specimen locations for AWS welder qualification. Place the number of the positions and pipe sizes in the blank below the appropriate illustration.


Top of pipe for 5G and 6G positions
45°
Side bend
Side bend
Side bend
Side bend

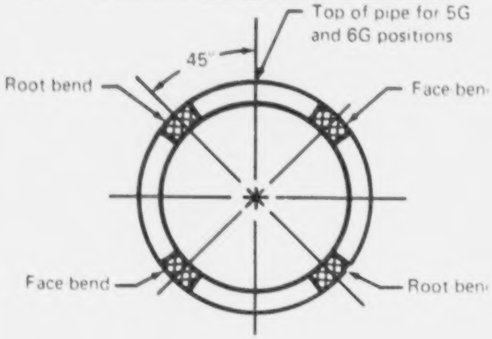
a. ______________________


Side bend
Side bend

b. ______________________


Face bend
Root bend

c. ______________________


Top of pipe for 5G and 6G positions
45°
Root bend
Face ben
Face bend
Root ben

d. ______________________

1. 1G and 2G positions for pipe $\frac{3}{8}$" and under
2. 1 G and 2G positions for pipe over $\frac{3}{8}$"
3. 5G and 6G positions for pipe $\frac{3}{8}$" and under
4. 5G and 6G positions for pipe over $\frac{3}{8}$"

***Permission to duplicate this test is granted.**

Pipe Welding Techniques and Applications
Unit 3

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Job Sheet 1—Bevel and Prepare Pipe for Welding Rating _____

Comments: ______________________________________

____

Job Sheet 2—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Horizontal Position Rating _____

Comments: ______________________________________

____

Job Sheet 3—Conduct Root- and Face-Bend Tests and a Nick-Break Test on Welded Pipe Rating _____

Comments: ______________________________________

____

Job Sheet 4—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Vertical Up Position Rating _____

Comments: ______________________________________

____

Job Sheet 5—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Vertical Up, 45° Inclined Position Rating _____

Comments: ______________________________________

____

Job Sheet 6—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Vertical Down Position Rating _____

Comments: ______________________________________

____

Unit Evaluation Form

Job Sheet 7—Weld to Specifications a V-Groove Butt Joint on 6" Schedule 40 Pipe in the Vertical Down, 45° Inclined Position Rating ______

Comments: ____________________

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____________________

Teacher Signature ____________________ Date __________

Student Signature ____________________ Date __________

***Permission to duplicate this form is granted.**

Pipe Welding Techniques and Applications
Unit 3

Teacher Supplement 1—Contractor's Welder Qualification Tests Record

Welder's name: ______________________________ **Identification no.** ________________

Title of standard governing qualification: ______________________________________

Welding procedure specification no. ________________________ Test no. ______________

Welding process(es) ____

Base metal _______________ P-number _______________ to P-number _______________

Pipe diameter ______________________________ Group Number ________________

Filler metal _________________________________ Pipe wall thickness ________________

Classifications ______________________________ A-number _____________________

Filler metal size ______________________________ No. of beads or passes ______________

Approx. volts ________________________________ Approx. amps __________________

Pipe position: 1G_____ 2G_____ 5G_____ 6G_____ 1F_____ 2F_____ 4F_____ 5F_____

Direction of welding ____ (uphill, downhill)

Electrical characteristics: DCRP ____________ DCSP ____________ AC ____________

Gas shielding: Gas(es) ____________ Flow rate ____________

Backing: Consumable insert (class and type) _____________ Backing ring ______________

Gas(es) ______________ Flow rate: ______________ Volume: ______________

Test results

Visual inspection results: ____

____

Teacher Supplement 1

Radiographic results:

Radiograph No.	Results	Radiograph No.	Results

Sectional or macrostructural examination or fillet weld fracture test results:

Specimen No.	Results	Specimen No.	Results

Guided-bend test results:

Type	Specimen no.	Results	Type	Specimen no.	Results
Face			Face		
Root			Root		
Side			Side		

Pressure bend test results: ______________________________

Special tests: ______________________________

Test conducted by: ______________________ Date ____________

Pipe Welding Techniques and Applications
Unit 3

Information Sheet

1. **Terms and definitions**

    a. **API (American Petroleum Institute)** — An organization that sets standards for transmission line pipe, joint design, fit-up, welding, and inspection

    b. **AR 1** — AWS specifications for qualification of welding procedures and welders at a level that applies to nuclear, chemical, and other systems where a high degree of weld quality is required

    c. **AR 3** — AWS specifications for qualification of welding procedures and welders at a level that applies to low-pressure heating, air conditioning, and other systems where an average degree of weld quality is required

    d. **ASME (American Society of Mechanical Engineers)** — An organization that sets standards for the design, construction, and welding of boilers and other high-pressure vessels

    e. **Coupon** — A selected area cut from a weld and the adjacent base metal for use in testing the quality of a weld

    f. **Cover or cap pass** — The final pass or passes that rise slightly above the outside surface of a pipe weld

    g. **Fill passes** — Welds that are deposited between the hot pass and the cover pass, and vary in number depending on pipe thickness

    h. **High-low condition** — A situation where one of two pipes in a joint is higher or lower than the pipe to which it is welded

    i. **Hot pass** — The second pass in a pipe welding procedure

    j. **Nipple** — A short length of pipe used for training or for qualifying pipe welders

    k. **Root face** — The squared off portion at the base of a pipe nipple

    l. **Root pass** — The first pass applied in a pipe weld; it is made without appreciable weaving motion and sometimes called a stringer bead

    m. **Root opening** — The separation at the base of pipe nipples when they are aligned with each other

Information Sheet

2. Guidelines for beginning pipe welders

a. Follow all safety rules regarding proper clothing and handling electrical equipment.

b. Develop the good habit of handling all pipe with care because even a short piece of pipe can seriously injure a foot if it is carelessly dropped.

c. When hand-cutting or machine-cutting bevels, make them as neat and clean as possible, and remember that proper joint preparation is one of the most important parts of pipe welding.

d. Develop the good habit of carefully cleaning all passes before finishing a pipe weld, and remember that visually inspecting every pass is a requirement.

e. Practice the pipe welding test positions and concentrate your learning activities on the procedures that will produce quality welds that will pass both nondestructive and destructive testing.

3. AWS electrode classifications for mild steel and alloy electrodes

a. The prefix "E" designates arc-welding electrode.

b. The first two digits of 4-digit numbers and the first three digits of 5-digit numbers indicate minimum tensile strength:

E60XX	60,000-psi Tensile Strength
E70XX	70,000-psi Tensile Strength
E110XX	110,000-psi Tensile Strength

c. The next-to-last digit indicates position:

EXX1X	All positions
EXX2X	Flat position and horizontal fillet

d. The last two digits together indicate the type of covering and the current to be used.

Information Sheet

e. The last letter and digit (EXXX-A-1) indicate the approximate alloy in the deposit:

-A1	½% Mo
-B1	½% C4, ½% Mo
-B2	1¼% Cr, ½% Mo
-B3	2¼% Cr, 1% Mo
-C1	2½% Ni
-C2	3¼% Ni
-C3	1% Ni, 35% MO, 15% Cr
-D1 & D2	.25-.45% MO, 1.25-2.00% Mn
-G	.50 min Ni, .30 min Cr., .20 min No, .10 min Ni, .30 min Cr., .20 min Mo, .10 mm V (Only one of the listed elements is required.)

f. In addition to the AWS classification system, electrodes are also classified according to the bare end diameter expressed in fractions of an inch.

Note: See Student Supplement 1 for additional information about electrodes.

4. Electrode selection for pipe welding

a. The EXX10 class electrodes are usually used for vertical-down cross-country pipe welding because of their special operating characteristics.

b. EXX10 electrodes produce a steady, concentrated arc which leaves a continuous bead inside the pipe when the root pass is made.

c. Because they produce a thin slag covering, the EXX10 electrodes give good wetting to the sides of the groove, but do not run into the crater and interfere with the arc.

d. When used properly, EXX10 electrodes produce minimum pinholes.

e. For vertical up pipe welding, EXX10 electrodes are normally used for the root pass, and EXX18 electrodes are used for all other passes.

f. Certain alloy pipes require low-alloy, low-hydrogen electrodes.

g. For x-ray quality welds, low-hydrogen electrodes such as E7018, E9018, and others are frequently specified to meet standards for high pressure, high strength applications.

Note: After low-hydrogen electrodes are removed from their moisture-proof containers, they should be stored in heating ovens at a minimum of 250°F.

Information Sheet

5. Guidelines for joint preparation, fit-up, and alignment

a. Since joint preparation is critical to fit-up, cut bevels to required angles, remove all slag, and grind the bevels free of imperfections.

b. Grind root faces or lands to specified width with no irregular contours.

c. For proper fit-up, align pipes or fittings to common centering or reference points without the need for hammering.

Note: Hammering may be required, but it is not recommended for fit-up or alignment.

d. Make joint preparation as exact as possible to avoid putting an extra burden on a welder who must spend extra time to compensate for this problem.

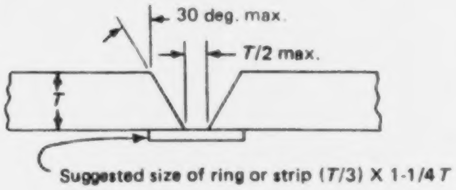
e. Make joint preparation as exact as possible to avoid a piping system that may not function or subject the installation to unsafe performance.

6. Guidelines for joint dimensioning

a. A joint without a root face should be prepared with a maximum 30° angle.

b. Joints without root faces should be separated a distance no more than half the thickness of the pipe.

c. Joints without root faces should use a backup ring or strip with a thickness equal to ⅓ the thickness of the pipe and a length equal to about 1¼ times the pipe thickness.

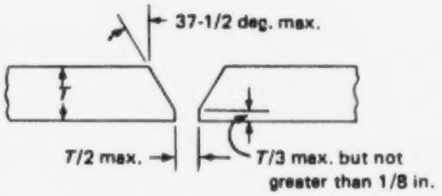


Courtesy American Society of Mechanical Engineers
from the *1989 ASME Boiler and Pressure Vessel Code*

d. A joint with a root face should be prepared with a maximum 37.5° angle, and the root face itself should be ⅓ the thickness of the pipe but no more than ⅛″.

Information Sheet

e. Joints with root faces should be separated a distance no more than half the thickness of the pipe.



Courtesy American Society of Mechanical Engineers
from the *1989 ASME Boiler and Pressure Vessel Code*

Note: Groove dimensions may vary depending on the governing welding code.

7. Guidelines for joint preparation

a. Use a portable grinder to prepare a root face, and remember that a root face too thin will contribute to burn-through, and a root face too thick may contribute to poor penetration.

b. After beveling with the oxyfuel cutting process, remove any remaining slag with a file.

c. Use a power brush to remove scale from the groove surface, and to remove rust and/or contaminants ½" from the outer edge of grooves.

Note: See Student Supplement 1 for AWS grinding and visual inspection requirements.

8. Common methods of pipe alignment

Note: The procedures and illustrations in this objective are adapted from materials published by the **Union Carbide Corporation, Linde Division**, and are reprinted with permission.

a. Pipe-to-pipe:

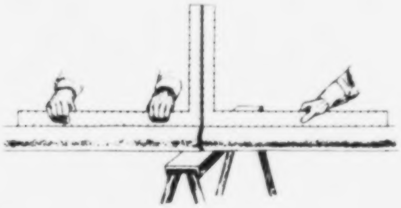
(1) Use pipe jacks or a level working surface and move pipes together until the pipe bevels are nearly butted and space is left for a welding gap.

(2) Center squares on top of the pipes and move up and down as required until pipes are aligned, then tack weld top and bottom.

Information Sheet

(3) Center squares on sides of the pipes and move back and forth until pipes are aligned, then tack weld each side.

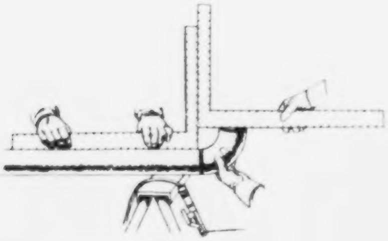
Note: An alternate method for this procedures is to align pipes with an angle iron.



b. 90° elbow-to-pipe:

(1) Use pipe jacks or a level working surface and place elbow bevel and pipe bevel in line and tack weld on top.

(2) Center square on top of pipe and center second square on open end of elbow, then move elbow until squares are aligned and tack weld on bottom.



c. 45° elbow-to-pipe:

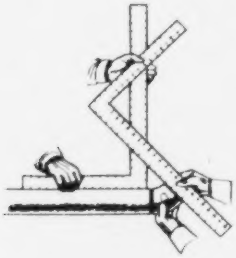
(1) Use pipe jacks or a level working surface and place elbow bevel and pipe bevel in line and tack weld on top.

(2) Center square on top of pipe, then cross square over open face of elbow to obtain 45° angle.

(3) Align the same numbers on the inside square of the tilted square with the same numbers on the other square (4 and 7 are typical alignment numbers).

Information Sheet

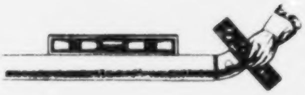
(4) Move elbow until numbers are in line, then tack weld bottom.



d. 45° elbow-to-pipe using levels:

(1) Use pipe jacks or a level working surface and place elbow bevel and pipe bevel in line and tack weld on top.

(2) Center spirit level on pipe, then center level on open end of elbow, move elbow until 45° bubble is centered, and tack weld on bottom.

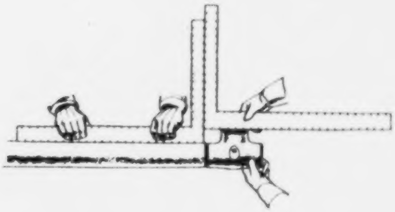


e. Tee-to-pipe:

(1) Use pipe jacks or a level working surface and place tee and pipe bevels so they are nearly butted and space is left for a welding gap.

(2) Align pipe and tee and tack weld on top.

(3) Center square on top of pipe, then center the second square on the tee branch outlet, move tee until squares are aligned, and tack weld on bottom.



Information Sheet

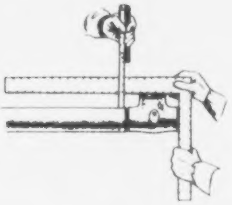
f. Tee to pipe with square and rule:

(1) Use pipe jacks or level working surface and place tee and pipe bevels so they are nearly butted and space is left for a welding gap.

(2) Align pipe and tee and tack weld on top.

(3) Center square across tee branch outlet so that it runs parallel with the pipe.

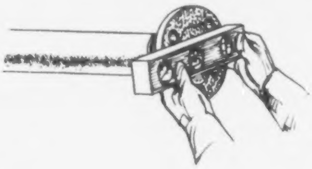
(4) Center rule on top of pipe, move rule to several different points to check alignment, adjust as required, then tack weld on bottom.



g. Flange to pipe:

(1) Butt flange to pipe and align top two holes of flange with a level.

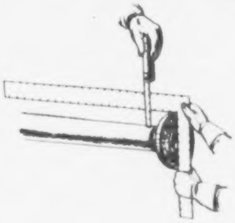
(2) Adjust flange until bubble is centered and make tack weld on top.



(3) Center square on face of flange and center rule on top of pipe.

(4) Move flange until square and pipe are parallel and tack weld on bottom.

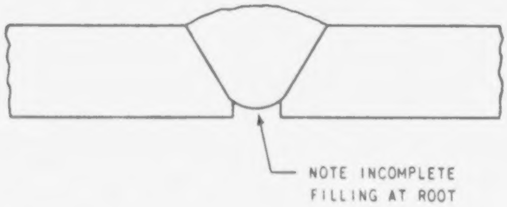
(5) Center square on face of flange so that it runs along the side of the pipe, then center rule on side of pipe, align, and tack both sides.



Information Sheet

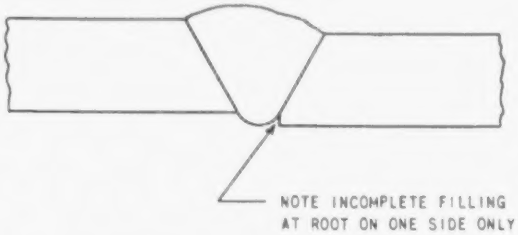
9. **Common pipe welding problems and their causes**

   a. **Inadequate penetration** — Failure to completely fill the weld root with weld metal


NOTE INCOMPLETE
FILLING AT ROOT

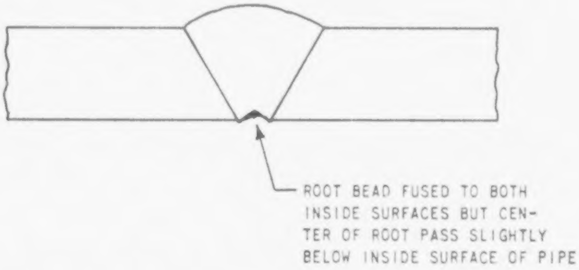
Courtesy American Petroleum Institute

   b. **Inadequate penetration due to high-low** — Failure to completely fill the weld root with weld metal because of pipe misalignment


NOTE INCOMPLETE FILLING
AT ROOT ON ONE SIDE ONLY

Courtesy American Petroleum Institute

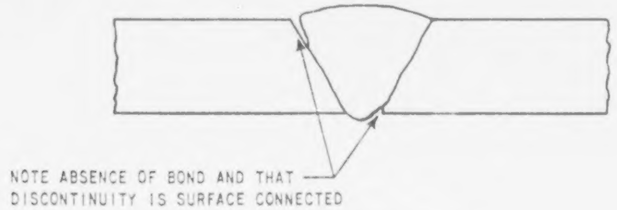
   c. **Internal concavity (suck back)** — A condition which causes the center of the root bead to have a surface that is below the inside surface of the pipe


ROOT BEAD FUSED TO BOTH
INSIDE SURFACES BUT CEN-
TER OF ROOT PASS SLIGHTLY
BELOW INSIDE SURFACE OF PIPE

Courtesy American Petroleum Institute

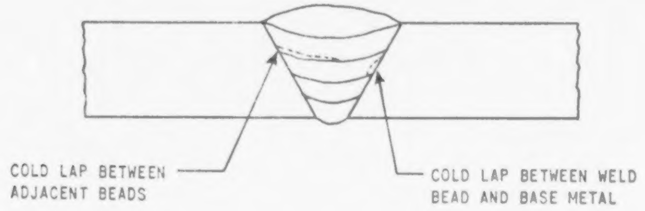
Information Sheet

d. **Incomplete fusion** — Incomplete tie-in at the root or top of the joint between the weld metal and the pipe surfaces


NOTE ABSENCE OF BOND AND THAT DISCONTINUITY IS SURFACE CONNECTED

Courtesy American Petroleum Institute

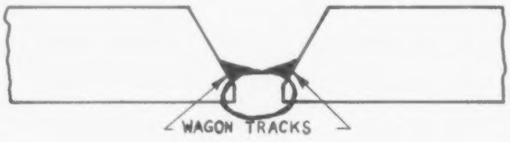
e. **Cold lap** — A lack of fusion between two adjacent weld beads or between a weld bead and the adjacent pipe surface


COLD LAP BETWEEN ADJACENT BEADS
COLD LAP BETWEEN WELD BEAD AND BASE METAL

Courtesy American Petroleum Institute

f. **Burn-through** — Occurs when excessive penetration causes the weld puddle to blow into the pipe

g. **Slag inclusion** — Occurs when nonmetallic solids from the flux are trapped in the weld metal or between the weld metal and the pipe, and long slag inclusions are called wagon tracks because they run along the undercut sides of a stringer pass


WAGON TRACKS

Courtesy American Petroleum Institute

Information Sheet

h. **Porosity** — Gas pockets or voids that occur in the weld metal or on the surface

i. **Undercut** — A groove melted into the base metal adjacent to the weld toe or weld root, and left unfilled by weld metal

j. **Cracks** — Hot cracking indicates problems with filler metals or the welding procedure, and cold cracking indicates problems with filler metals or problems in the base metals of the pipe

10. Pipe welding troubleshooting chart

Problem	Probable Cause	Corrective Procedures
Porosity	Chemical reactions that take place during welding, too long an arc, wind, or atmospheric conditions	Check for proper amperage Reduce arc length Check dryness of electrode
Slag Inclusion	Rapidly solidifying slag, nonmetallic elements from flux, too low welding current, and improper cleaning	Check for proper amperage Check welding technique Correct contours by grinding Check joint preparation and fit-up
Incomplete Fusion	Failure to raise base or metal to melting point, and oxides from improper fluxing	Check joint preparation and fit-up Check root gap and root face Use smaller electrode Use high welding current Slow travel speed
Undercutting	High amperage and long arc, incorrect electrode position, wrong travel speed, and bad welding technique	Reduce amperage and arc length Correct electrode angle Adjust travel speed Remove by grinding

11. Ways to prevent pipe welds from cracking

a. Make the stringer bead as small as possible and practical.

b. Leave line-up clamps on pipe until stringer bead is completed.

c. Make the hot pass as soon after the stringer bead as possible, within five minutes.

Information Sheet

d. When temperature is below 40°F, preheat the pipe according to wall thickness or manufacturers specifications.

e. Do not start or end passes at the same point as the pass underneath.

f. Use low-hydrogen electrodes.

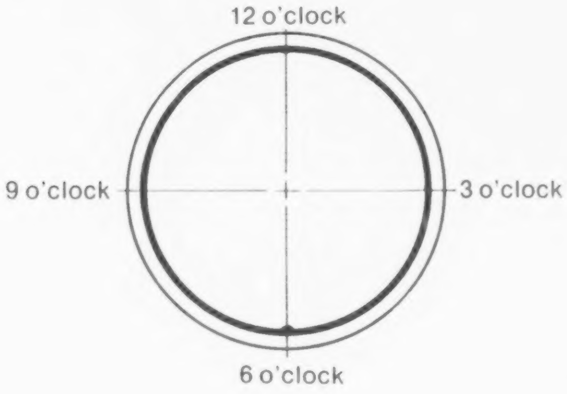
g. Clean each pass thoroughly.

h. Grind stops and starts of each electrode prior to restart.

12. The concept of quartering

a. Quartering is the process of moving in sequence from one quarter of a pipe to an opposite quarter of a pipe to maintain proper alignment, control heat transfer, and reduce distortion.

b. For convenient reference, quartering positions are stated as they are related to numbers on the face of a clock.



c. Two quarters or full half passes are also referenced as clock positions.

Example: Weld vertically down from 12 to 6 o'clock, and reverse for uphill.

13. Performance qualification for pipe welding

a. A qualification test is conducted with two pipe nipples joined by a procedure specified for preparation, fit-up, and welding.

b. Specifications for a qualification test include every step of the welding procedure including such highly detailed items such as characteristics of the oxyfuel flame and travel speed in inches per minute for each pass.

c. Records of a qualification test are maintained until the procedure they test is no longer in use.

Information Sheet

14. Qualification testing and its importance in pipe welding

a. Procedure qualification testing is a process of using destructive tests to qualify a welding procedure for a specific manufacturer to make sure the procedure produces the required results.

b. Welder qualification testing is a process used to qualify welders to make sure they are skilled enough to make the types of welds required for a specific application.

c. Destructive testing is accomplished by using test specimens or coupons cut from selected areas of a weld.

d. Nondestructive testing may be used as an alternate method to qualify welder performance.

e. Testing for both procedure and welder qualification is documented so that problems can be pin-pointed and corrected.

f. Procedure qualification tests document many variables ranging from electrode size to weather conditions; discontinuities are carefully recorded and sometimes sketched for clarification.

15. Methods of pipe inspection

a. Nondestructive testing includes visual inspection or radiographic testing or other tests as specified by a given company.

b. Destructive testing includes:

    (1) Tensile test

    (2) Nick-break test

    (3) Root-bend test

    (4) Face-bend test

    (5) Side-bend test

16. Specimen locations for AWS welding procedure qualification

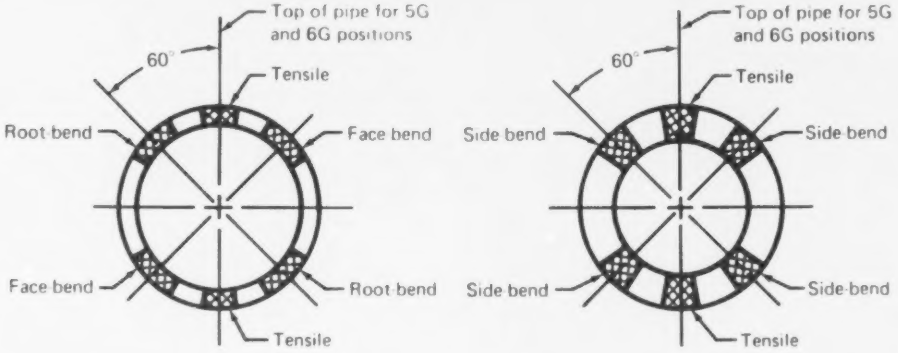
a. AWS specifications require that test specimens for a procedure qualification be taken from specific locations on a welded test pipe.

b. The locations where specimens may be taken from a test weld vary with the pipe diameter, and the required test procedure varies with the pipe schedule.

Information Sheet

c. In both the 5G and 6G positions, sample welds from 6″ schedule 40 pipe call for root-bends and face-bends from the sidewall of the pipe, but for 6″, 8″, and 10″ schedule 120 pipe, sample welds call for a side-bend at all sidewall positions.

Note: The following examples are from AWS D10.9-80, and demonstrate specimen locations for the AR-1 level of welding procedure qualification.


Top of pipe for 5G and 6G positions
60°
Tensile
Root bend
Face bend
Face bend
Root bend
Tensile
Top of pipe for 5G and 6G positions
60°
Tensile
Side bend
Side bend
Side bend
Side bend
Tensile

6 in. sch. 40 sample welds

6 in., 8 in., and 10 in. sch. 120 sample welds

Specimen locations

Courtesy American Welding Society

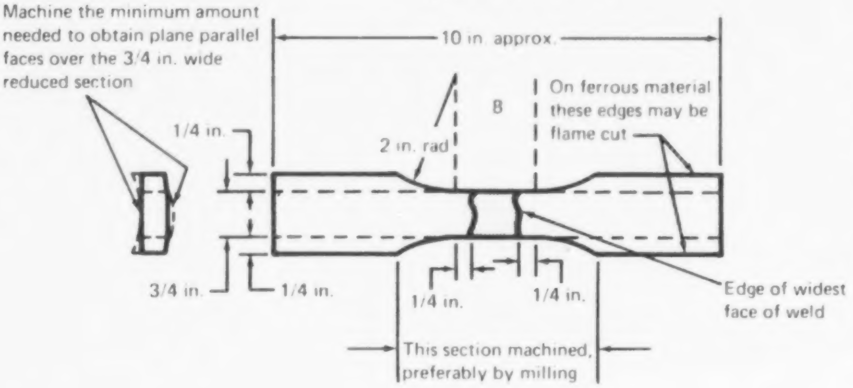
Information Sheet

17. AWS specifications for specimen preparation

a. A specimen must not only be cut from a specified place on a test pipe, the specimen must be prepared according to the nature of the test to which it will be subjected.

b. A tensile test specimen will literally be pulled apart and requires careful preparation with respect to dimensions, machining, and milling.

Pipe wall 3/8 in. or less


Machine the minimum amount needed to obtain plane parallel faces over the 3/4 in. wide reduced section
10 in. approx.
1/4 in.
2 in. rad
B
On ferrous material these edges may be flame cut
3/4 in.
1/4 in.
1/4 in.
1/4 in.
Edge of widest face of weld
This section machined, preferably by milling

Tensile specimen

SI Equivalents

in.	mm
1/4	6.4
3/4	19.0
2	51
6	152
8	203
10	254

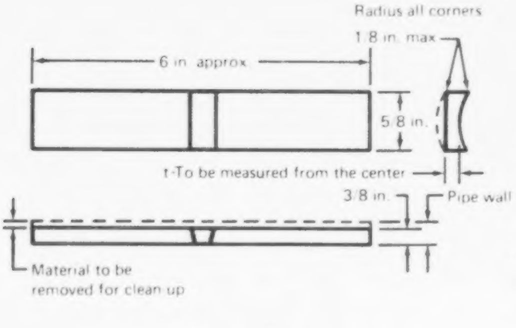
Notes:

1. All dimensions in inches.
2. Weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. Cut surfaces shall be smooth and parallel.

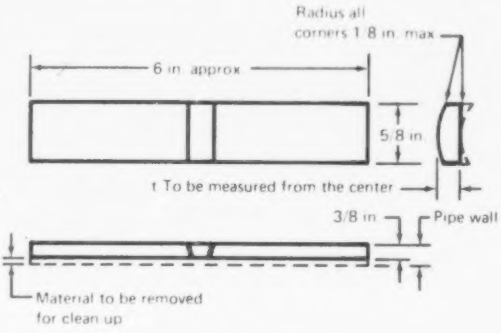
Courtesy American Welding Society

Information Sheet

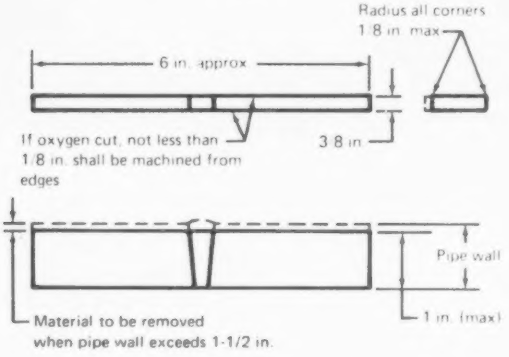
c. Root-bend, face-bend, and side-bend specimens require specimens approximately 6″ long with special radius requirements on the corners and limitations on materials removed by machining.


Radius all corners
1/8 in. max
6 in. approx
5/8 in.
t-To be measured from the center
3/8 in.
Pipe wall
Material to be removed for clean up

Root-bend specimen


Radius all corners 1/8 in. max
6 in. approx
5/8 in.
t To be measured from the center
3/8 in.
Pipe wall
Material to be removed for clean up

Face-bend specimen


Radius all corners
1/8 in. max
6 in. approx
If oxygen cut, not less than 1/8 in. shall be machined from edges
3/8 in.
Pipe wall
1 in. (max)
Material to be removed when pipe wall exceeds 1-1/2 in.

Side-bend specimen
(for pipe over 3/8 in. thick)

SI Equivalents

in.	mm
1/8	3.2
3/8	9.5
5/8	15.9
1	25.4
6	152

Notes:

1. All dimensions in inches.
2. Weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. Cut surfaces shall be smooth and parallel.

Courtesy American Welding Society

d. After root-bend, face-bend, and side-bend specimens are properly prepared, they should be tested in a guided-bend jig or with a wraparound tester.

Information Sheet

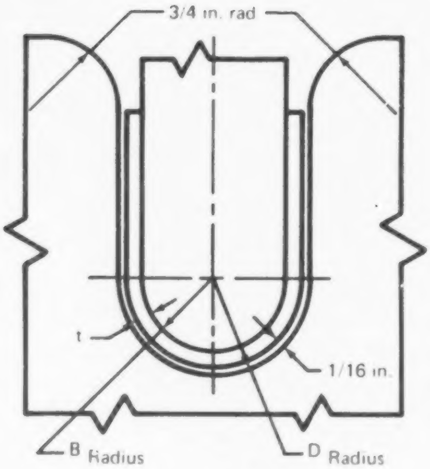
e. Both guided-bend and wraparound testers are available from manufacturers, but in all cases, they need to comply with specifications and be used for specific specimen thicknesses.

Sample thicknesses and jig dimensions[a,b]

(See Table 2)	Sample thickness,		Specimen thickness,		Radius of bend, B,		Radius of die, D,	
	in.	mm	in.	mm	in.	mm	in.	mm
All except P23	t		t		3-1/3t		4-1/3t − 1/16	1.6
	0.375	9.5	0.375	9.5	1-1/4	32.0	1-11/16	43.0
P23 (and F23)	t < 0.125	3.2	t		8-1/4t		9-1/4t + 1/16	1.6
	t > 0.125	3.2	0.125 (face-, root-, or side-bend)	3.2	1-1/32	26.0	1-7/32	31.0

a. t = the wall thickness of the sample weld.

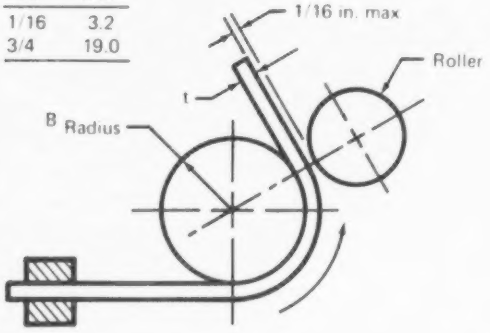
b. For sample welds in P23 materials whose thickness exceeds 0.125 in. (3.2 mm), remove and bend specimens of 0.125 in. (3.2 mm) thickness as required to cover the wall thickness under test.



Schematic view of guided-bend jig

SI Equivalents

in.	mm
1/16	3.2
3/4	19.0



Schematic view of wraparound jig

Note: All dimensions in inches.

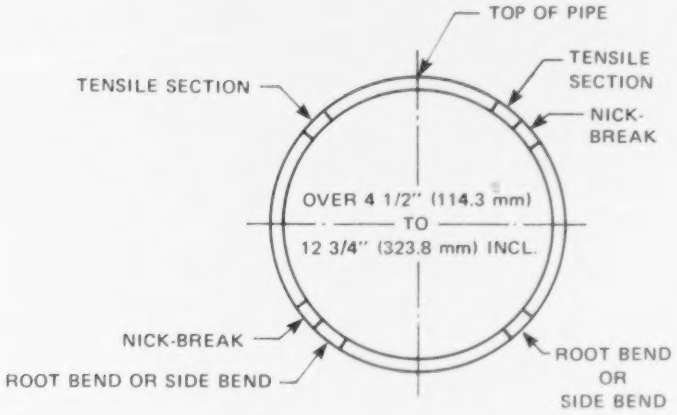
Courtesy American Welding Society

Information Sheet

18. API procedure qualifications

a. Because API specifications are for pipeline welding, their procedure qualification differs from specifications for industrial welding.

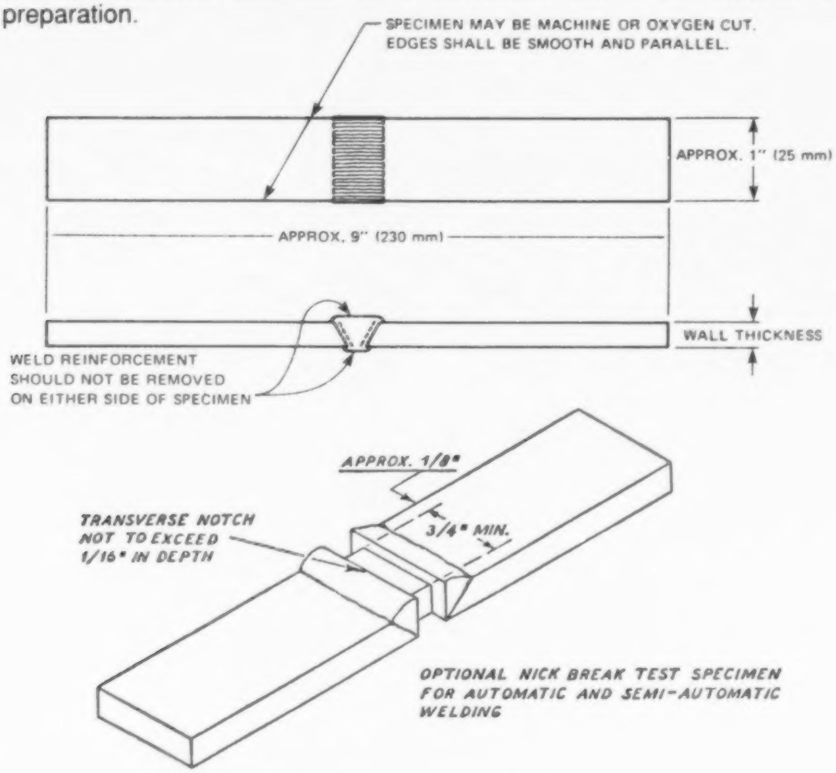
b. In particular, tensile sections for API testing are taken from positions at approximately one o'clock and seven o'clock.


TOP OF PIPE
TENSILE SECTION
TENSILE SECTION
NICK-BREAK
OVER 4 1/2" (114.3 mm)
TO
12 3/4" (323.8 mm) INCL.
NICK-BREAK
ROOT BEND OR SIDE BEND
ROOT BEND OR SIDE BEND

Courtesy American Petroleum Institute

Information Sheet

c. API specifications also call for a nick-break test which requires special preparation.


SPECIMEN MAY BE MACHINE OR OXYGEN CUT.
EDGES SHALL BE SMOOTH AND PARALLEL.
APPROX. 1" (25 mm)
APPROX. 9" (230 mm)
WALL THICKNESS
WELD REINFORCEMENT
SHOULD NOT BE REMOVED
ON EITHER SIDE OF SPECIMEN
APPROX. 1/8"
3/4" MIN.
TRANSVERSE NOTCH
NOT TO EXCEED
1/16" IN DEPTH
OPTIONAL NICK BREAK TEST SPECIMEN
FOR AUTOMATIC AND SEMI-AUTOMATIC
WELDING

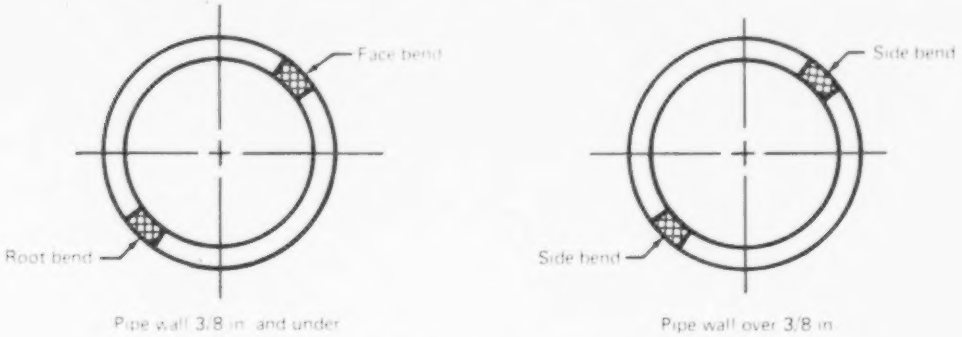
Courtesy American Petroleum Institute

Information Sheet

19. Specimen locations for AWS welders qualification

a. AWS specifications for welder qualification vary in type and number according to the pipe size and the position being tested.

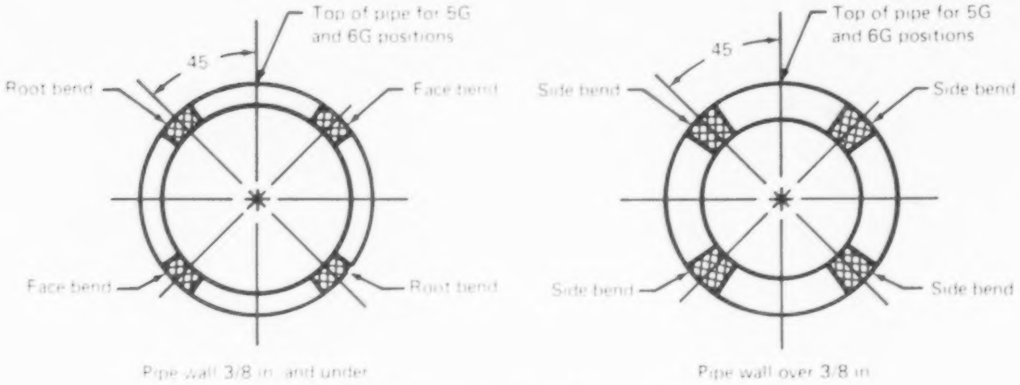
b. For the 1G and 2G positions, AWS requires one root-bend and one face-bend for pipe ⅜" and under, and two side-bends for pipe over ⅜".


Face bend
Root bend
Pipe wall 3/8 in. and under
Side bend
Side bend
Pipe wall over 3/8 in.

Location of specimens for 1G and 2G positions

Courtesy American Welding Society

c. For the 5G and 6G positions, AWS requires two root-bends and two face-bends for pipe ⅜" and under and four side-bends for pipe over ⅜".


Top of pipe for 5G and 6G positions
45
Root bend
Face bend
Face bend
Root bend
Pipe wall 3/8 in. and under
Top of pipe for 5G and 6G positions
45
Side bend
Side bend
Side bend
Side bend
Pipe wall over 3/8 in.

Location of specimens for 5G and 6G positions

Courtesy American Welding Society

Note: Qualification in both the 2G and 5G positions qualifies for welding in any position, and qualification in the 6G position qualifies for welding in any position. For procedure and welder qualification specifications for API and ASME, see Student Supplement 2 and 3.

Pipe Welding Techniques and Applications
Unit 3

Student Supplement 1—AR-1 Level of AWS Standards for Visual Inspection and Grinding

Note: for convenience, the following specifications are presented with their reference numbers as they appear in *Specifications for Qualification of Welding Procedures for Piping and Tubing, AWS D10.9-80.*

1.2.4 Typical applications are as follows:

1.2.4.1 AR-1. This level applies to systems where a high degree of weld quality is required. Typical applications are lines in nuclear, chemical, cryogenic, gas, or steam systems.

1.2.4.2 AR-3. This level applies to systems where an average degree of weld quality is required. Applications are lines such as those for low-pressure heating, air conditioning, sanitary water, and some gases or chemicals.

3.2 Tests Required for Sample Groove Welds. Details regarding specimen preparation, testing techniques, and acceptance requirements for qualification of a welder to the AR-1 level follow.

3.2.1 Visual Inspection. Each sample weld shall be inspected visually with the unaided eye:

(1) *Prior to assembly* of the test pieces, to assure that the proper materials are being used, that the parts have been cleaned, and that the end preparation is correct.

(2) *After fit-up*, to check the joint clearances.

(3) *During welding*, to inspect for cracks, porosity, undercut, incomplete fusion, surface roughness, and poor crater conditions. Grinding may be used when necessary on starts and stops and to remove local defects from bead-to-bead, but dressing of the completed sample weld shall be limited to the removal of local defects appearing on the outer surface of the weld reinforcement. *If production welding is to be accomplished from the outside of the pipe only, no repair of the root of the sample weld from the inside of the pipe is permitted.*

Student Supplement 1

(4) *After welding has been completed* (including any postheating), to detect any surface defects. The following are the acceptance requirements for a sample weld to pass visual inspection:

- (a) The specified base metal and filler metal shall have been used.
- (b) The weld shall be free of cracks.
- (c) All caters shall be filled to the full cross section of the weld and shall be free of cracks upon completion of the welding.
- (d) The face of the weld shall be at least flush with the outside surface of the pipe, and the weld shall merge smoothly with the base metal. Depth of the weld undercut shall not exceed 1/32 in. (0.8 mm), irrespective of length. Weld reinforcement shall not exceed the following:

Sample weld pipe size,		Face reinforcement, max,	
in.	mm	in.	mm
½	13	3/32	2.4
2 or 3	51-76	⅛	3.2
4 and over	102	3/16	4.8

- (e) The root of the weld shall be examined, and there shall be complete joint penetration and no cracks, nor incomplete fusion. A concave root surface is permitted within the limits shown in (f) below, provided the total weld thickness is equal to or greater than that of the base metal.
- (f) A concave root surface and root reinforcement are permitted within the limits shown below:

Limits of surface imperfections on the inside surface of the joint

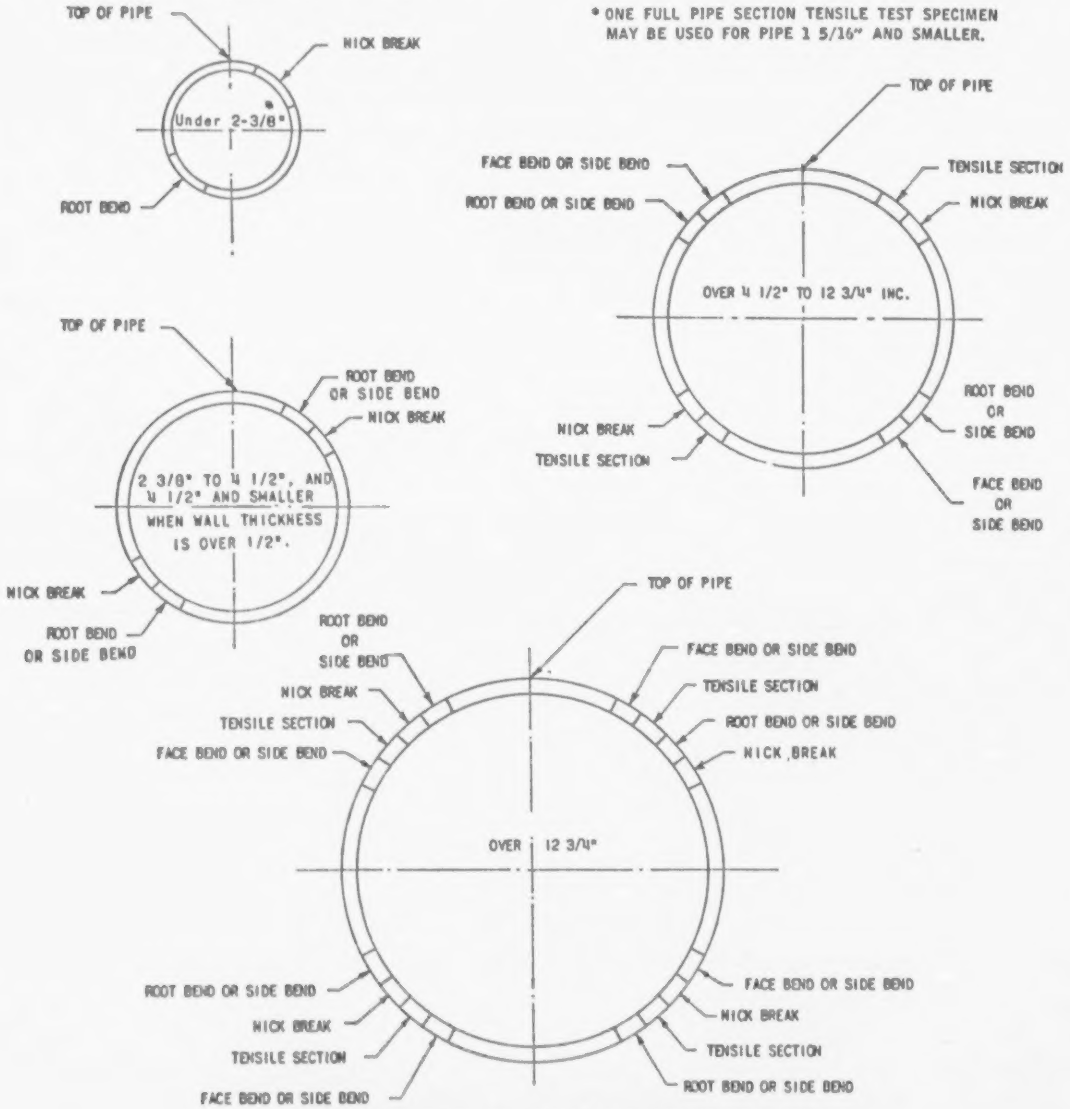
Sample weld pipe size,		Maximum root surface concavity,		Maximum root reinforcement,	
in.	mm	in.	mm	in.	mm
½	13	1/32	0.8	1/16	1.6
2 or 3	51-76	1/16	1.6	1/16	1.6
4 and over ≤0.75 in. wall	102	1/16	1.6	3/32	2.4
6 and over >0.75 in. wall	152	1/16	1.6	⅛	3.2

Courtesy American Welding Society

Pipe Welding Techniques and Applications
Unit 3

Student Supplement 2—Welding Procedure and Welding Performance Specifications from API

1. Welding procedure specifications


TOP OF PIPE
NICK BREAK
Under 2-3/8"
ROOT BEND
TOP OF PIPE
FACE BEND OR SIDE BEND
ROOT BEND OR SIDE BEND
TENSILE SECTION
NICK BREAK
OVER 4 1/2" TO 12 3/4" INC.
ROOT BEND OR SIDE BEND
NICK BREAK
TENSILE SECTION
FACE BEND OR SIDE BEND
TOP OF PIPE
ROOT BEND OR SIDE BEND
NICK BREAK
2 3/8" TO 4 1/2", AND 4 1/2" AND SMALLER WHEN WALL THICKNESS IS OVER 1/2".
NICK BREAK
ROOT BEND OR SIDE BEND
TOP OF PIPE
ROOT BEND OR SIDE BEND
NICK BREAK
TENSILE SECTION
FACE BEND OR SIDE BEND
FACE BEND OR SIDE BEND
TENSILE SECTION
ROOT BEND OR SIDE BEND
NICK BREAK
OVER 12 3/4"
ROOT BEND OR SIDE BEND
NICK BREAK
TENSILE SECTION
FACE BEND OR SIDE BEND
FACE BEND OR SIDE BEND
NICK BREAK
TENSILE SECTION
ROOT BEND OR SIDE BEND

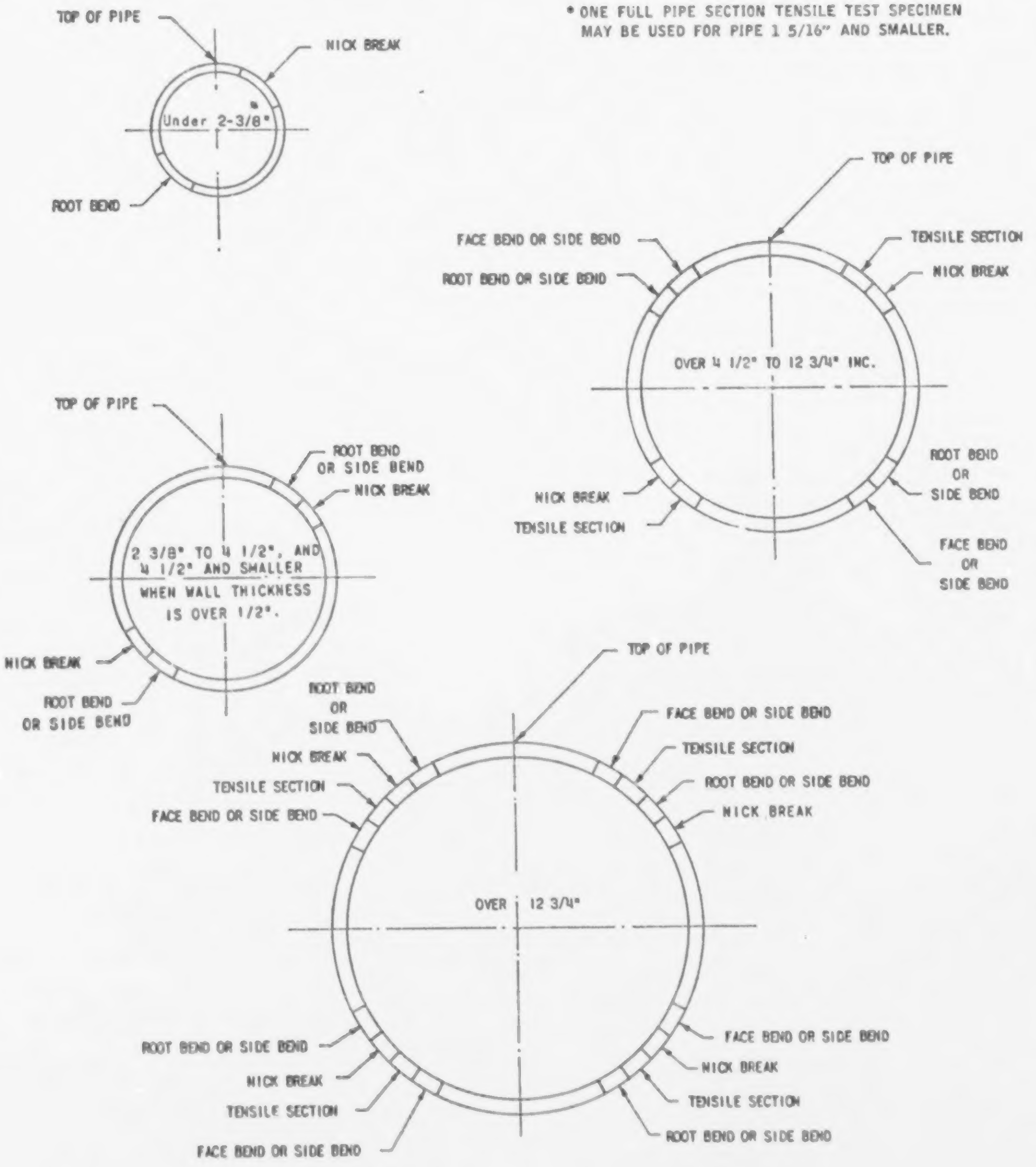
* ONE FULL PIPE SECTION TENSILE TEST SPECIMEN MAY BE USED FOR PIPE 1 5/16" AND SMALLER.

AT THE COMPANY'S OPTION, THE LOCATIONS MAY BE ROTATED 45 DEGREES COUNTERCLOCKWISE OR THEY MAY BE EQUALLY SPACED AROUND THE PIPE EXCEPT SPECIMENS SHALL NOT INCLUDE THE LONGITUDINAL WELD. ALSO, AT THE COMPANY'S OPTION, ADDITIONAL SPECIMENS MAY BE TAKEN.

Courtesy American Petroleum Institute

Student Supplement 2

2. Welding performance specifications


TOP OF PIPE
NICK BREAK
Under 2-3/8"
ROOT BEND
TOP OF PIPE
FACE BEND OR SIDE BEND
ROOT BEND OR SIDE BEND
TENSILE SECTION
NICK BREAK
OVER 4 1/2" TO 12 3/4" INC.
NICK BREAK
TENSILE SECTION
ROOT BEND OR SIDE BEND
FACE BEND OR SIDE BEND
TOP OF PIPE
ROOT BEND OR SIDE BEND
NICK BREAK
2 3/8" TO 4 1/2", AND 4 1/2" AND SMALLER WHEN WALL THICKNESS IS OVER 1/2".
NICK BREAK
ROOT BEND OR SIDE BEND
TOP OF PIPE
ROOT BEND OR SIDE BEND
NICK BREAK
TENSILE SECTION
FACE BEND OR SIDE BEND
FACE BEND OR SIDE BEND
TENSILE SECTION
ROOT BEND OR SIDE BEND
NICK BREAK
OVER 12 3/4"
ROOT BEND OR SIDE BEND
NICK BREAK
TENSILE SECTION
FACE BEND OR SIDE BEND
FACE BEND OR SIDE BEND
NICK BREAK
TENSILE SECTION
ROOT BEND OR SIDE BEND

* ONE FULL PIPE SECTION TENSILE TEST SPECIMEN MAY BE USED FOR PIPE 1 5/16" AND SMALLER.

AT THE COMPANY'S OPTION, THE LOCATIONS MAY BE ROTATED 45 DEGREES COUNTERCLOCKWISE OR THEY MAY BE EQUALLY SPACED AROUND THE PIPE EXCEPT SPECIMENS SHALL NOT INCLUDE THE LONGITUDINAL WELD. ALSO, AT THE COMPANY'S OPTION, ADDITIONAL SPECIMENS MAY BE TAKEN.

Courtesy American Petroleum Institute

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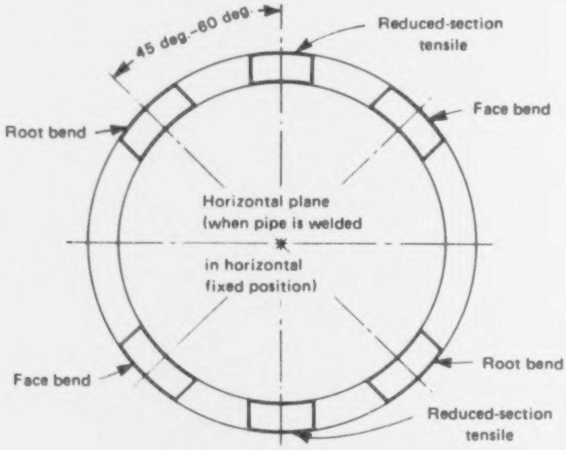
Pipe Welding Techniques and Applications
Unit 3

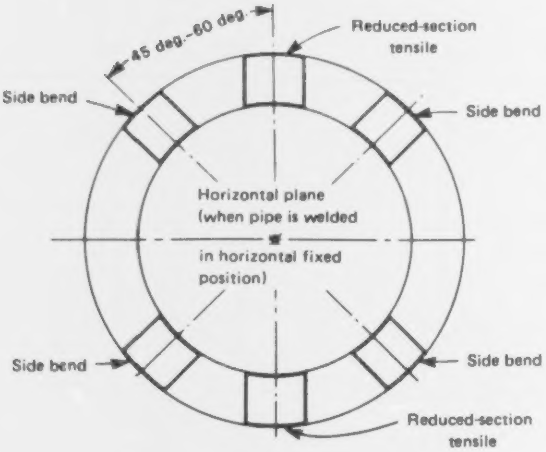
Student Supplement 3—Welding Procedure and Welding Performance Specifications from ASME

1. Welding procedure specifications


45 deg.-60 deg.
Reduced-section tensile
Face bend
Root bend
Horizontal plane (when pipe is welded in horizontal fixed position)
Face bend
Root bend
Reduced-section tensile

Pipes - 1/16 to 3/4 in. Thickness

QW-463.1(d) PROCEDURE QUALIFICATION


45 deg.-60 deg.
Reduced-section tensile
Side bend
Side bend
Horizontal plane (when pipe is welded in horizontal fixed position)
Side bend
Side bend
Reduced-section tensile

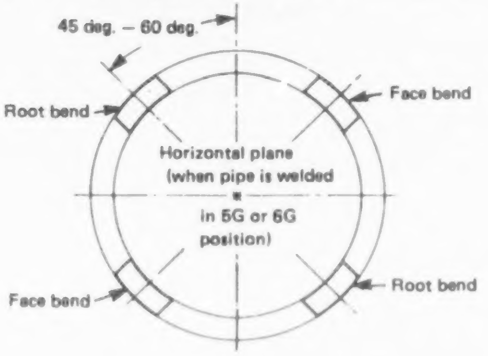
Piper - Over 3/4 in. Thickness and Alternate
From 3/8 in. but Less Than 3/4 in. Thickness

QW-463.1(e) PROCEDURE QUALIFICATION

Courtesy American Society of Mechanical Engineers
from the *1989 ASME Boiler and Pressure Vessel Code*

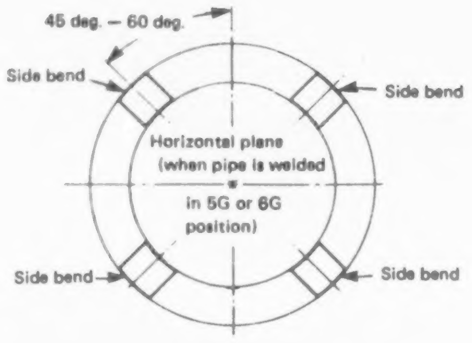
Student Supplement 3

2. Welding performance specifications


45 deg. – 60 deg.
Root bend
Face bend
Horizontal plane (when pipe is welded in 5G or 6G position)
Face bend
Root bend

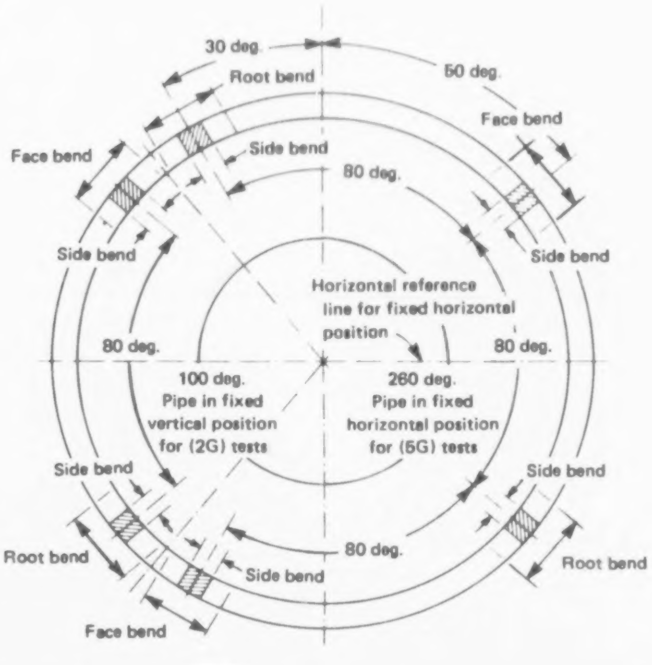
Pipes — 1/16 Up to 3/4 in. Thickness

QW-463.2(d) PERFORMANCE QUALIFICATION


45 deg. – 60 deg.
Side bend
Side bend
Horizontal plane (when pipe is welded in 5G or 6G position)
Side bend
Side bend

Pipes — 3/4 in. and Over Thickness and Alternate From 3/8 in. but Less Than 3/4 in. Thickness

QW-463.2(e) PERFORMANCE QUALIFICATION


30 deg.
Root bend
50 deg.
Face bend
Side bend
80 deg.
Face bend
Side bend
Side bend
Horizontal reference line for fixed horizontal position
80 deg.
80 deg.
100 deg. Pipe in fixed vertical position for (2G) tests
260 deg. Pipe in fixed horizontal position for (5G) tests
Side bend
Side bend
Root bend
80 deg.
Side bend
Root bend
Face bend

GENERAL NOTE:
When side-bend tests are made in accordance with QW-452.1 and QW-452.3, they shall be removed as shown in QW-463.2(f) in place of the face and root bends.

Courtesy American Society of Mechanical Engineers
from the *1989 ASME Boiler and Pressure Vessel Code*

Pipe Welding Techniques and Applications
Unit 3

Job Sheet 1—Bevel and Prepare Pipe for Welding

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Pipe cleaning	______
Pipe beveling	______
Inspection	______

A. Tools and materials

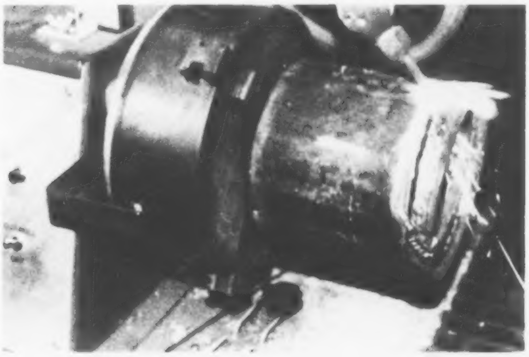
- Oxyacetylene cutting unit
- Chipping hammer and wire brush
- Portable grinder and cup brush
- Cutting goggles and spark lighter
- Steel pipe, 6″, schedule 40
- Pliers and file
- Pipe beveling machine
- Wraparound and soapstone
- Jack stands
- Retractable steel tape
- Bench vise
- Personal safety clothing
- Face shield and safety glasses

Job Sheet 1

B. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated; note the location of the nearest fire extinguisher.

Note: If you are using a pipe beveling machine that rotates the pipe nipple, the following procedure will require modification.



☐ 2. Position the pipe on jack stands so that about 3′ of pipe extends over the end jack stand to provide a comfortable working distance.

☐ 3. Use the portable grinder with a cup brush to clean about a 14″ length of pipe that extends over the jack stand.

☐ 4. Clamp the pipe beveling machine onto the pipe so positioned that the torch tip at the end of the pipe can be adjusted to cut the required bevel angle.

Job Sheet 1

☐ 5. Crank the pipe beveling machine all the way around the pipe to check for proper tracking; make sure the tip stays an equal distance from the end of the pipe at all points on the circumference.

☐ 6. Position the torch at a top starting point.

☐ 7. Set up oxyacetylene cutting equipment according to safety standards.

☐ 8. Pull down cutting goggles and light and adjust torch to a neutral flame.

☐ 9. Check the distance from the inner cone of the flame to the pipe surface; it should be $^1/_{16}$″ to $^1/_8$″.

☐ 10. Move the torch slowly around the cutting line to preheat the pipe.

☐ 11. Return to the starting point and preheat that point until the metal turns a dull red to indicate a temperature of about 1550°F.

☐ 12. Open the oxygen cutting valve to start cutting, and then crank the beveling machine at a cutting speed that will make a good, clean cut.

☐ 13. Watch the cut and adjust cutting speed as required as you crank the beveling machine completely around the pipe until you finish the cut.

☐ 14. Shut down the oxyacetylene torch.

☐ 15. Inspect the bevel for a smooth, even cut.

> **Caution: Be careful around the hot end of the pipe, and let the pipe cool before placing the wraparound on it.**

☐ 16. Release the tension on the beveling machine and move it back far enough on the pipe to provide a comfortable space to use a wraparound, and then clamp the machine back in place.

> **Caution: Hang on to the beveling machine every time you clamp it or unclamp it to make sure it doesn't fall.**

☐ 17. Measure from the outer edge of the bevel you just cut to a distance 6″ back on the pipe and mark that point.

Job Sheet 1

☐ 18. Place the wraparound around the pipe so that the wraparound makes a double lap which will provide a reference for a true, straight line around the circumference of the pipe.

☐ 19. Mark the cutting line with soapstone along the edge of the wraparound and around the circumference of the pipe.

☐ 20. Remove the wraparound and put it in a safe place.

☐ 21. Release the tension on the beveling machine, move it back so that the torch tip lines up with the cutting line you just marked, and then clamp the machine onto the pipe again.

☐ 22. Make the cut by repeating the procedure you used with the first cut.

☐ 23. Use pliers to hold the nipple as the cut is finished so the hot nipple will not fall on your foot.

☐ 24. Shut off the torch.

☐ 25. Inspect your bevel for a smooth, even cut.

☐ 26. Have your instructor check your work.

☐ 27. Repeat the procedure previously outlined to cut more nipples, if you instructor so directs.

☐ 28. Shut down the oxyacetylene equipment, remove the torch from the beveling machine, and remove the beveling machine and return it to proper storage.

☐ 29. Secure the nipple(s) in a bench vise so that the axis of the pipe is perpendicular to the vise with the beveled end pointing upward.

☐ 30. Use a file to clean off any slag inside the nipple(s).

☐ 31. Use a portable grinder to grind a 1/16″ to 3/32″ root face on the bevel(s) so that nipples that will later be welded together have equal root faces to help avoid burn-through.

☐ 32. Have your instructor check your work.

☐ 33. Check in tools and materials and clean the area.

Evaluator's comments: ______________________________

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Pipe Welding Techniques and Applications
Unit 3

Job Sheet 2—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

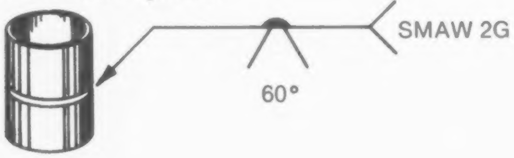
Evaluation criteria	Rating
Equipment setup and safety	______
Alignment and gap wire use	______
Tack welds and feathering	______
Quartering technique	______
Root pass and cleaning	______
Fill passes and cleaning	______
Cap pass, cleaning, and inspection	______

A. Tools and materials

SMAW machine with accessories
Chipping hammer and wire brush
Portable grinder with wire brush
6″ schedule 40 pipe nipples
Electrodes as specified
Gap wire as specified (root opening may vary)
Straightedge or piece of angle iron
Pliers
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 2

2. Electrode: EXX10, EXX18, 3⁄32″ or 1⁄8″
3. Electrical: DCEP
4. Position: 2G
5. Technique: Whip and drag
6. Cleaning: Grind and brush
7. Testing: Bend

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

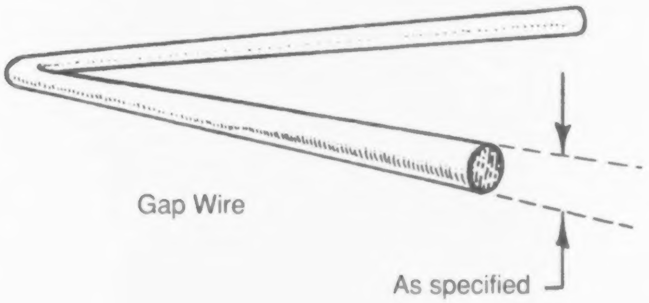
☐ 2. Attach ground cable to work table or workpiece.

☐ 3. Select correct polarity for electrode.

☐ 4. Turn on SMAW machine.

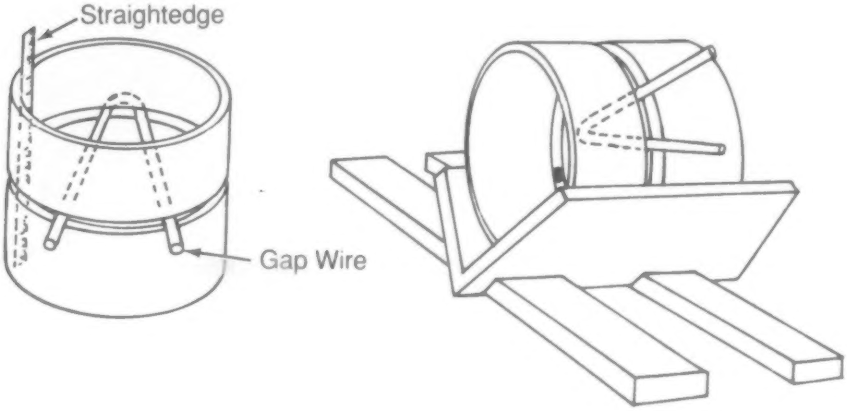
☐ 5. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.

☐ 6. Place two 6″ nipples on work table positioned so that one is on top of the other to form a vertical axis with a proper gap wire placed between the two.



Job Sheet 2

☐ 7. Place a straightedge inside the nipples to align them vertically, or lay the nipples in a piece of angle iron to align them horizontally.



☐ 8. Tack weld the members in place according to the following procedure:

   a. Start between the spread ends of the gap wire and make the first tack weld.

   b. Move 180° opposite the first tack weld, pull the gap wire out from between the two nipples, use one end of the gap wire to recheck the gap at that point, then make the second tack weld.

   c. Move 90° in either direction from the second tack weld and make the third tack weld.

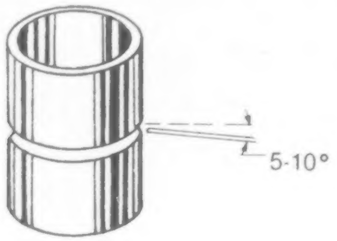
   d. Move 180° opposite the third tack weld and make the fourth tack weld.

☐ 9. Feather all tack welds with a grinder, but be careful not to grind all the way through the tack weld.

☐ 10. Place the nipples so that they are in the position indicated in specifications.

Job Sheet 2

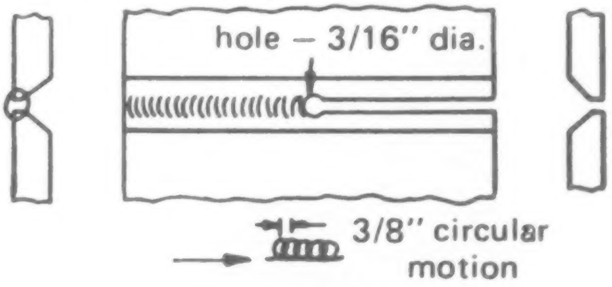
☐ 11. Place electrode in electrode holder and adjust to correct electrode angle.



☐ 12. Strike an arc on one of the feathered tacks and quickly adjust to proper arc length.

> **Caution: Strike the arc only in the weld zone and not on the finished sides of the pipe.**

☐ 13. Make a puddle and immediately form a keyhole.



Electrode Travel

☐ 14. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod back and forth, always move the rod back to the center of the keyhole, and keep electrode arcing in the middle of the joint and not on the outer portion of the bevel.

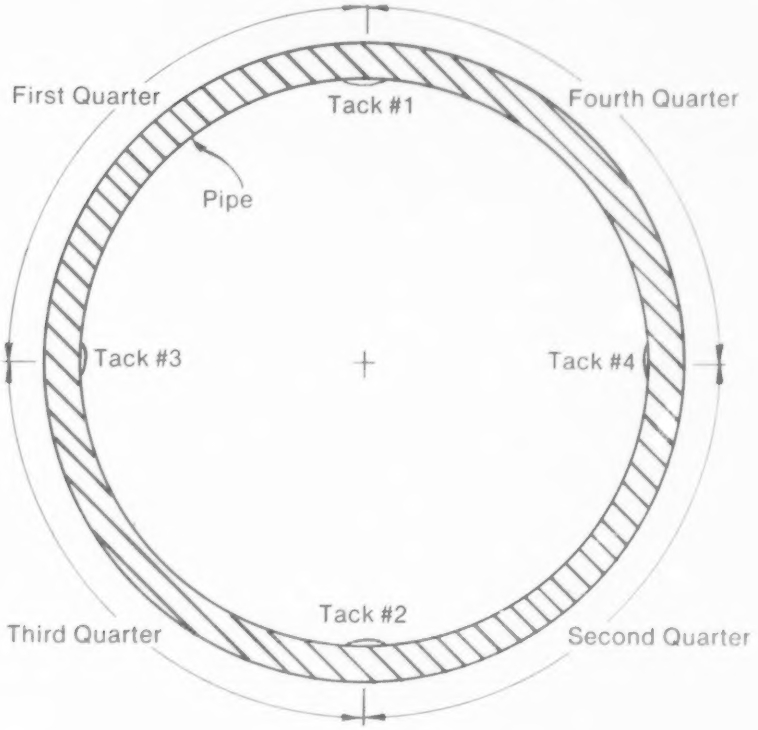
☐ 15. Weld to the center of the next tack weld, stop, then use quartering to control heat and distortion as you finish the stinger.

☐ 16. Go 90° around the pipe from your stopping point, strike an arc at the tack weld there, and weld to the center of the next tack weld and stop.

Job Sheet 2

☐ 17. Go 180° around the pipe from your second stopping point, strike an arc at the tack weld there, and weld to the center of the next tack weld and stop where the previous bead started.

☐ 18. Go 90° around the pipe from your third stopping point, strike an arc where the previous bead ended on the tack weld there, and weld to the center of the next tack weld and stop where the previous bead started.



☐ 19. Chip slag off stringer bead, brush it, then grind the entire bead with a hand grinder.

☐ 20. Inspect the root pass for good fusion and penetration and for defects such as undercutting on both outside and inside surfaces.

☐ 21. Adjust amperage to the proper setting for an EXX18 electrode.

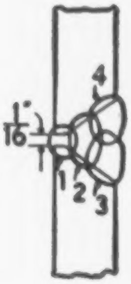
☐ 22. Use the electrode with a drag technique, run a hot pass over the entire stinger bead, and take care not to burn through the stringer.

Job Sheet 2

☐ 23. Chip slag off hot pass, brush it, and grind off any high spots.

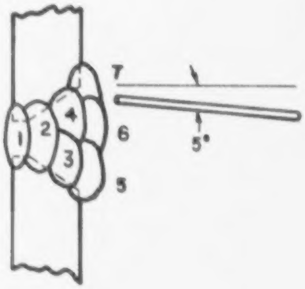
☐ 24. Use the same electrode, and with a drag technique, lay stringer beads for remainder of fill-up, and be sure to clean each pass before starting another one.

Note: The numbers in the following illustration indicate sequence and not quantity.



☐ 25. Clean fill-up stringer beads thoroughly.

☐ 26. Use the same electrode, and with a drag technique, lay the cap passes to finish the weld.



☐ 27. Clean and inspect the cap passes.

☐ 28. Have your instructor check your work.

☐ 29. Shut down SMAW equipment.

☐ 30. Conduct a bend test as outlined in Job Sheet 3.

☐ 31. Have your instructor check your bend test.

Job Sheet 2

☐ 32. Check in tools and materials and clean up area.

Evaluator's comments: ____________________

____

____

Pipe Welding Techniques and Applications
Unit 3

Job Sheet 3—Conduct Root- and Face-Bend Tests and a Nick-Break Test on Welded Pipe

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Specimen preparation	______
Face-bend test	______
Root-bend test	______
Nick-break test	______

A. Tools and materials

Bend test machine
Oxyacetylene cutting unit
Portable hand grinder
Pliers and file
Steel rule and soapstone
Cutting goggles and sparklighter
Groove-welded test pipe from previous job sheet
Bench vise
Ball peen hammer
Hacksaw
Personal safety clothing and safety glasses

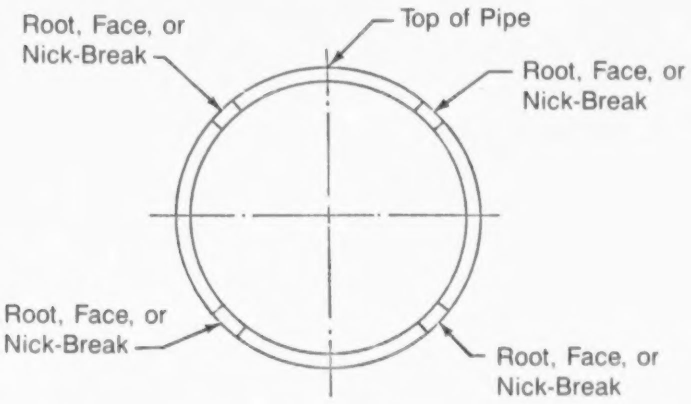
B. Procedure

☐ 1. Check the work area to make sure it is free of flammable materials and well ventilated; note the location of the nearest fire extinguisher.

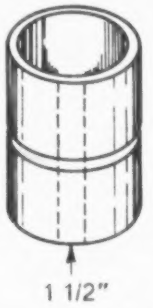
☐ 2. Place the test pipe on a work table so you can conveniently measure and mark the specimens for root, face, or nick-break tests as directed by your instructor.

Job Sheet 3

☐ 3. Determine a top starting point to work from and cut test specimens from each quarter as indicated in the following illustration.


Root, Face, or Nick-Break
Top of Pipe
Root, Face, or Nick-Break
Root, Face, or Nick-Break
Root, Face, or Nick-Break

☐ 4. Mark all test specimens so that they intersect the weld perpendicularly and are 1½″ wide, then cut specimens the full length of the pipe.



☐ 5. Cut off excess pipe so that each specimen is 6″ long with the weld centered.

☐ 6. Label specimens according to location as TR for top root, TF for top face, BR for bottom root, BF for bottom face, TN for top nick-break, and BN for bottom nick-break.

☐ 7. Allow specimens to air cool; do not quench them in water!

Job Sheet 3

☐ 8. Take cooled bend test specimens one at a time, secure each in a vise, grind off slag on cutting edges, and grind the welds so that the root and face of each weld is flush with the surface of the pipe.

Caution: Do not grind beneath the surface of the base metal or the specimen will be useless, and do all grinding so that it is perpendicular to the weld.

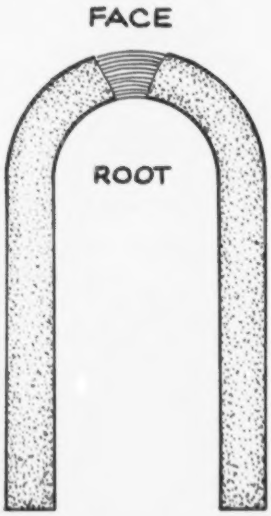
☐ 9. Have your instructor check your test specimens.

☐ 10. Take specimens to a plunger-type bend tester and make bend tests according to the following procedure:

Caution: Always wear safety glasses when conducting tests.

☐ 11. Place a face bend specimen on the die member of the jig with the face of the weld pointing into the die so that the plunger is on the root side of the weld.

☐ 12. Actuate the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

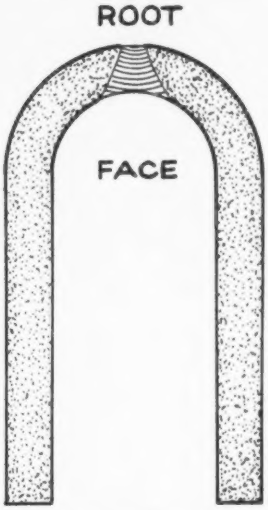


☐ 13. Release the plunger and remove the specimen.

Job Sheet 3

☐ 14. Place a root-bend specimen on the die member of the jig with the root of the weld pointing into the die so that the plunger is on the face side of the weld.

☐ 15. Actuate the plunger to force the specimen between the plunger and the die until it is formed into a U shape.



☐ 16. Release the plunger and remove the specimen.

☐ 17. Inspect test specimens according to the following procedure:

  a. Examine convex surface of both specimens for cracks or other defects.

  b. Check root bend to determine if welds have complete penetration through the joint.

  c. Check face bend to determine if there is complete fusion of the beveled edges with the welds.

☐ 18. Have your instructor check your bend tests.

☐ 19. Take cooled nick-break test specimens one at a time, secure each in a vise, cut and grind so that each specimen is 9″ long and 1″ wide with no weld reinforcement removed from either side of the specimen.

☐ 20. Take a hacksaw and cut a centered groove ⅛″ deep on each side of the weld reinforcement.

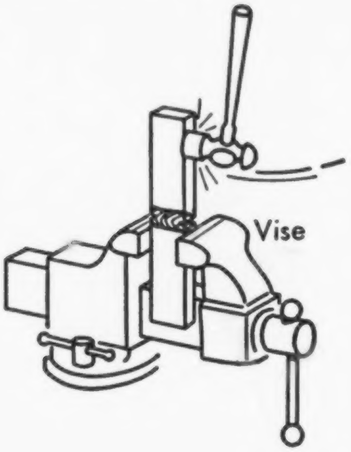
Job Sheet 3

☐ 21. Use a file or grinder to make edges smooth and parallel.

☐ 22. Have your instructor check your nick-break test specimens.

☐ 23. Take one nick-break specimen to a bench vise and secure it firmly perpendicular to the vise with the bottom edge of the weld positioned just above the jaws of the vise.

☐ 24. Strike the test specimen from one side with a ball peen hammer hard enough to break it with a single blow.



Courtesy Lincoln Electric Company

☐ 25. Put the other test specimen in the vise and repeat the procedure.

☐ 26. Check each nick-break test specimen for:

  a. Complete penetration and fusion.

  b. Gas pockets that exceed $\frac{1}{16}$" or gas pockets which combined cover more than 2% of the exposed surface area.

  c. Slag inclusion that are more than $\frac{1}{8}$" long or longer than ½ the nominal wall thickness of the pipe.

  d. At least ½" solid weld metal between any slag inclusions.

☐ 27. Have your instructor check your nick-break test specimens.

☐ 28. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Pipe Welding Techniques and Applications
Unit 3

Job Sheet 4—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Vertical Up Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Alignment and gap wire use	______
Tack welds and feathering	______
Quartering technique	______
Restart technique	______
Root pass and cleaning	______
Fill passes and cleaning	______
Cap pass, cleaning, and inspection	______
Bend test	______

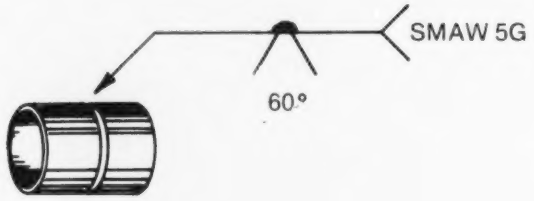
A. Tools and materials

SMAW machine with accessories
Chipping hammer and wire brush
Portable grinder with wire brush
6″ schedule 40 pipe nipples
Electrodes as specified (root opening may vary)
Straightedge or piece of angle iron
Pliers
Personal safety clothing and safety glasses

Job Sheet 4

B. Specifications

1. Joint design and weld symbol:



2. Electrode: EXX10, root pass; EXX18, filler and cap, 3/32", 1/8"
3. Electrical: DCEP
4. Position: 5G (fixed)
5. Direction: Vertical up
5. Technique: Whipping and weaving
6. Cleaning: Chip, brush, and grind
7. Testing: Bend test

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Attach ground cable to work table or workpiece.

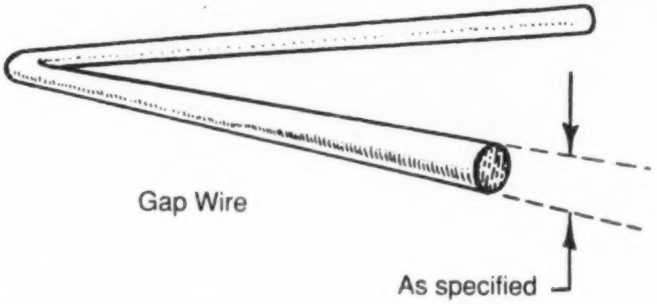
☐ 3. Select correct polarity for electrode.

☐ 4. Turn on SMAW machine.

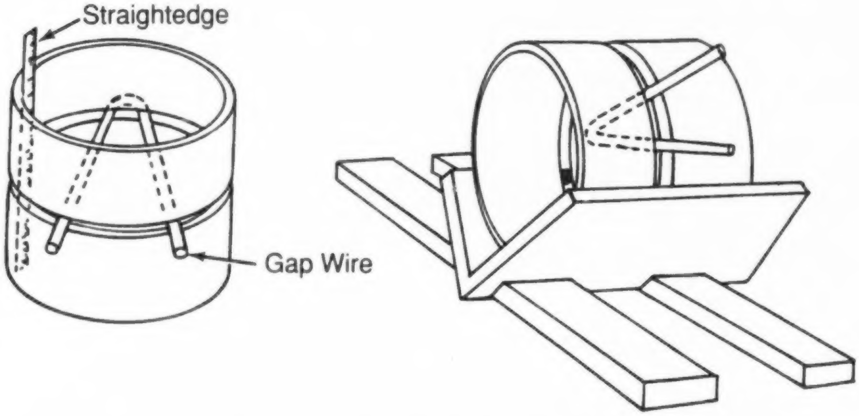
☐ 5. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.

Job Sheet 4

☐ 6. Place two 6" nipples on work table positioned so that one is on top of the other to form a vertical axis with a proper gap wire placed between the two.



☐ 7. Place a straightedge inside the nipples to align them vertically, or lay the nipples in a piece of angle iron to align them horizontally.



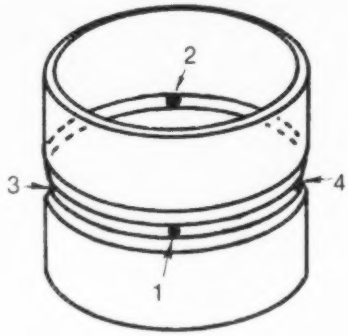
☐ 8. Tack weld the members in place according to the following procedure:

a. Start between the spread ends of the gap wire and make the first tack weld.

b. Move 180° opposite the first tack weld, pull the gap wire out from between the two nipples, use one end of the gap wire to recheck the gap at that point, then make the second tack weld.

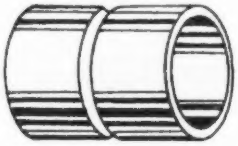
c. Move 90° in either direction from the second tack weld and make the third tack weld.

d. Move 180° opposite the third tack weld and make the fourth tack weld.

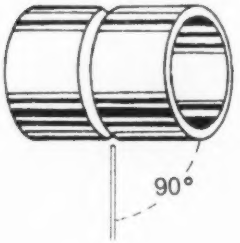


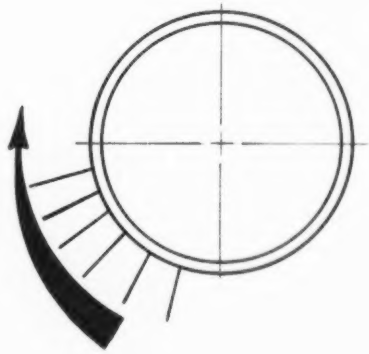
☐ 9. Feather all tack welds with a grinder, but be careful not to grind all the way through the tack weld.

☐ 10. Place the nipples so that they are in the position indicated in specifications.



☐ 11. Place E 6010 electrode in electrode holder and adjust to correct electrode angle.



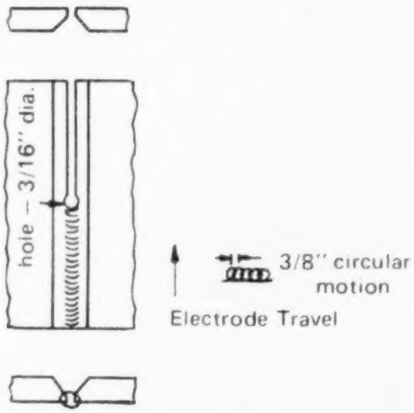


Job Sheet 4

☐ 12. Strike an arc on one of the feathered tacks at 3 o'clock (or 9 o'clock) and quickly adjust to proper arc length.

Caution: Strike the arc only in the weld zone and not on the finished sides of the pipe.

☐ 13. Make a puddle and immediately form a keyhole.

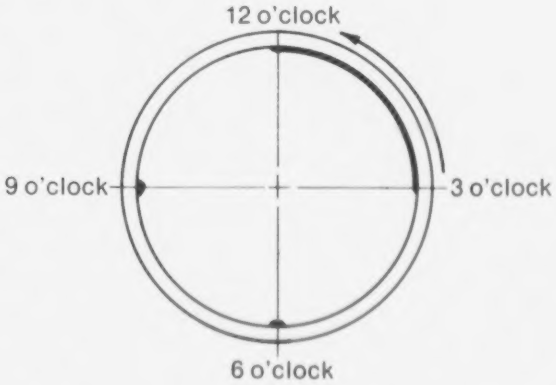


☐ 14. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

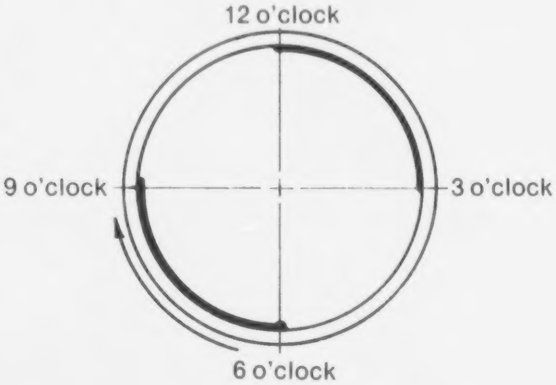
Note: Do not deposit filler metal outside the keyhole as you whip the rod back and forth, always move the rod back to the center of the keyhole, and keep electrode arcing in the middle of the joint and not on the outer portion of the bevel.

Job Sheet 4

☐ 15. Weld up to the center of the 12 o'clock tack weld and stop at the center point of the tack.

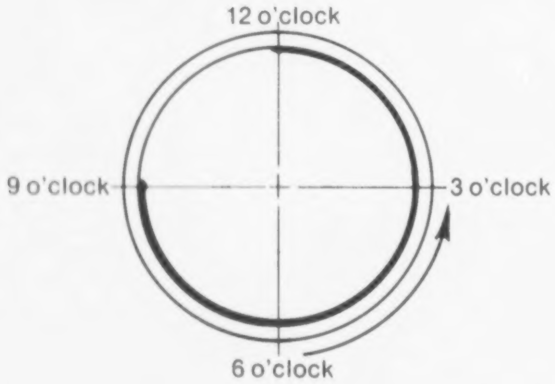

12 o'clock
9 o'clock
3 o'clock
6 o'clock

☐ 16. Restart arc at center of tack weld at 6 o'clock, form proper keyhole, and weld up to the center of the tack weld at 9 o'clock and stop.

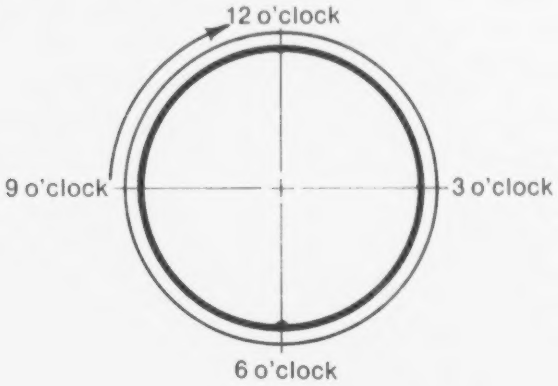

12 o'clock
9 o'clock
3 o'clock
6 o'clock

Job Sheet 4

☐ 17. Go back to the tack weld at 6 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld up to tack weld at 3 o'clock and tie-in with first quarter pass.



☐ 18. Go across to tack weld at 9 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld up to tack weld at 12 o'clock and tie-in with the first quarter pass.



☐ 19. Chip slag off stringer bead and brush it or grind the entire bead with a hand grinder.

☐ 20. Inspect the root pass for good fusion and penetration and for defects such as undercutting on both outside and inside surfaces.

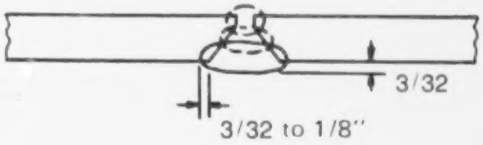
☐ 21. Adjust amperage to the proper setting for an EXX18 electrode.

☐ 22. Use the EXX18 electrode, and with a weaving technique, lay stinger beads for remainder of fill-up, and be sure to clean each pass before starting the next one.

Job Sheet 4

☐ 23. Clean fill-up stringer beads thoroughly.

☐ 24. Use the EXX18 electrode, and with a weaving technique, lay a cap pass to finish the weld with vertical up welding from 6 to 12 o'clock on each side.



☐ 25. Clean and inspect cap pass.

☐ 26. Have your instructor check your work.

☐ 27. Shut down SMAW equipment.

☐ 28. Conduct a bend test as outlined in Job Sheet 3.

☐ 29. Have your instructor check your bend test.

☐ 30. Check in tools and materials and clean up area.

Evaluator's comments: ______________________________

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Pipe Welding Techniques and Applications
Unit 3

Job Sheet 5—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Vertical Up, 45° Inclined Position

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	Rating
Equipment setup and safety	
Alignment and gap wire use	
Tack welds and feathering	
Quartering technique	
Restart technique	
Root pass and cleaning	
Fill passes and cleaning	
Cap pass, cleaning, and inspection	
Bend test	

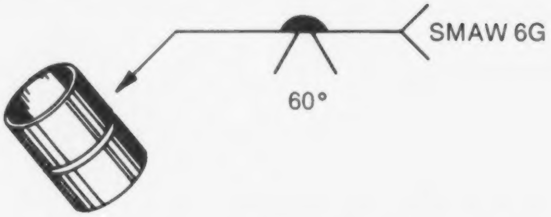
A. Tools and materials

SMAW machine with accessories
Chipping hammer and wire brush
Portable grinder with wire brush
6″ schedule 40 pipe nipples
Electrodes as specified
Gap wire as specified (root opening may vary)
Straightedge or piece of angle iron
Pliers
Personal safety clothing and safety glasses

Job Sheet 5

B. Specifications

1. Joint design and weld symbol:



2. Electrode: EXX10, root pass; EXX18, filler and cap, 3/32", 1/8"
3. Electrical: DCEP
4. Position: 6G (fixed)
5. Direction: Vertical up
5. Technique: Whipping and drag
6. Cleaning: Chip, brush, and grind
7. Testing: Bend test

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Attach ground cable to work table or workpiece.

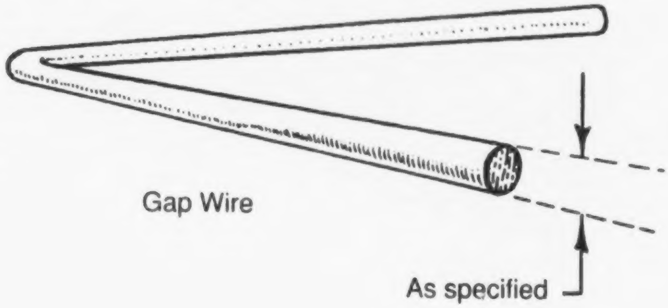
☐ 3. Select correct polarity of electrode.

☐ 4. Turn on SMAW machine.

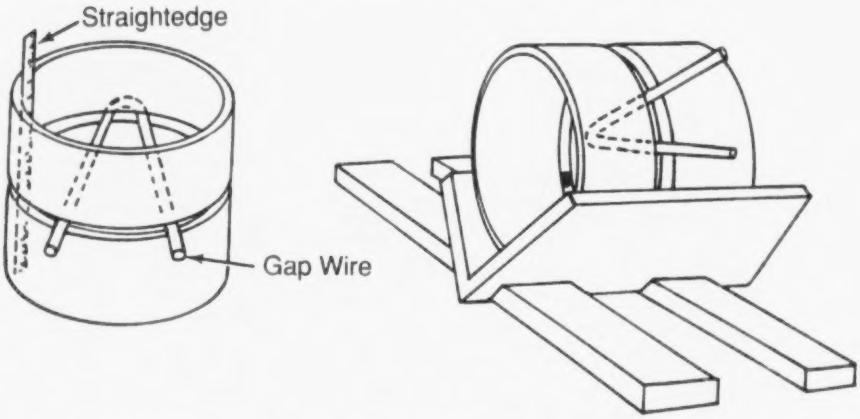
☐ 5. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.

Job Sheet 5

☐ 6. Place two 6″ nipples on work table positioned so that one is on top of the other to form a vertical axis with a proper gap wire placed between the two.



☐ 7. Place a straightedge inside the nipples to align them vertically, or lay the nipples in a piece of angle iron to align them horizontally.



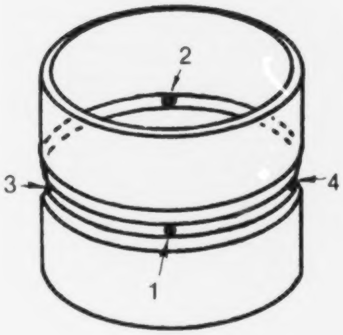
☐ 8. Tack weld the members in place according to the following procedure:

a. Start between the spread ends of the gap wire and make the first tack weld.

b. Move 180° opposite the first tack weld, pull the gap wire out from between the two nipples, use one end of the gap wire to recheck the gap at that point, then make the second tack weld.

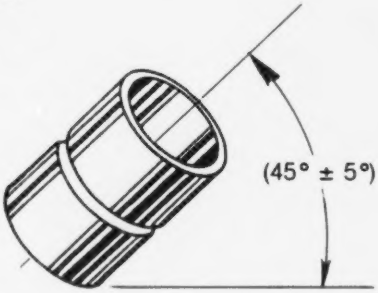
c. Move 90° in either direction from the second tack weld and make the third tack weld.

d. Move 180° opposite the third tack weld and make the fourth tack weld.

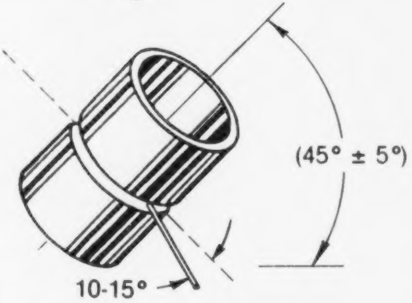


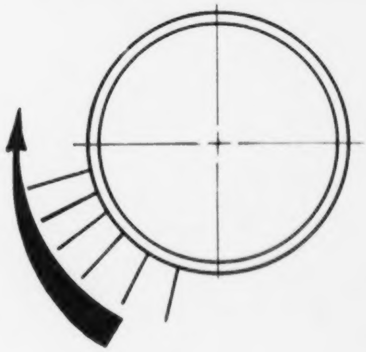
☐ 9. Feather all tack welds with a grinder, but be careful not to grind all the way through the tack weld.

☐ 10. Place the nipples so that they are in the position indicated in specifications.



☐ 11. Place EXX10 electrode in electrode holder and adjust to correct electrode angle.



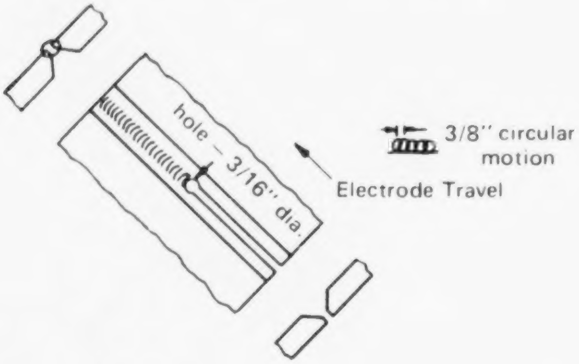


Job Sheet 5

☐ 12. Strike an arc on one of the feathered tacks at 3 o'clock (or 9 o'clock) and quickly adjust to proper arc length.

Caution: Strike the arc only in the weld zone and not on the finished sides of the pipe.

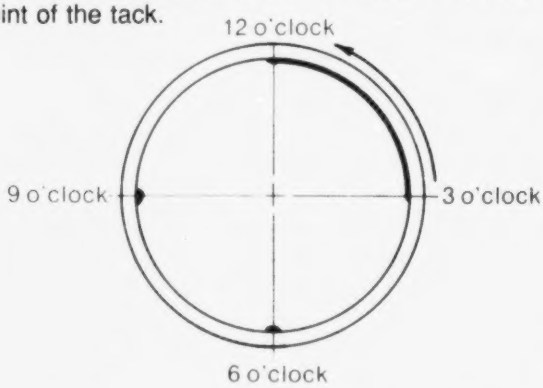
☐ 13. Make a puddle and immediately form a keyhole.


hole – 3/16" dia.
3/8" circular motion
Electrode Travel

☐ 14. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

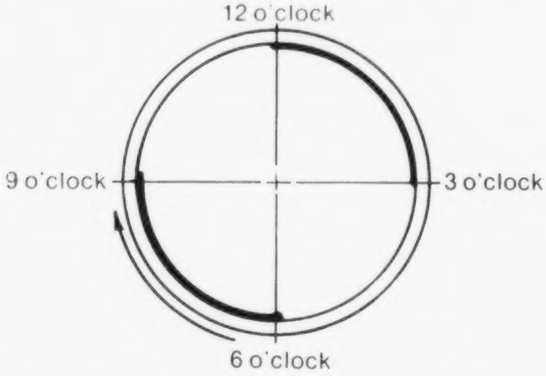
Note: Do not deposit filler metal outside the keyhole as you whip the rod back and forth, always move the rod back to the center of the keyhole, and keep electrode arcing in the middle of the joint and not on the outer portion of the bevel.

☐ 15. Weld up to the center of the 12 o'clock tack weld and stop at the center point of the tack.

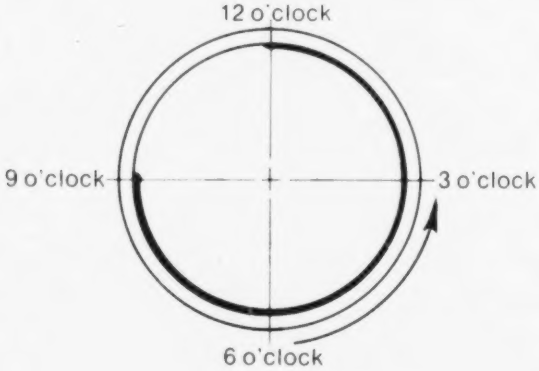

12 o'clock
9 o'clock
3 o'clock
6 o'clock

Job Sheet 5

☐ 16. Restart arc at center of tack weld at 6 o'clock, form proper keyhole, and weld up to the center of the tack weld at 9 o'clock and stop.

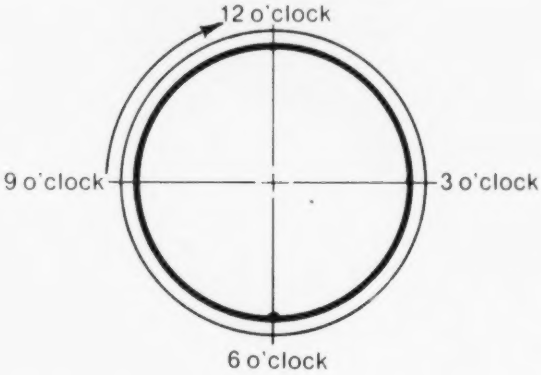

12 o'clock
9 o'clock
3 o'clock
6 o'clock

☐ 17. Go back to the tack weld at 6 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld up to tack weld at 3 o'clock and tie-in with first quarter pass.


12 o'clock
9 o'clock
3 o'clock
6 o'clock

Job Sheet 5

☐ 18. Go across to tack weld at 9 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld up to tack weld at 12 o'clock and tie-in with the first quarter pass.



☐ 19. Chip slag off stringer bead, brush it, then grind the entire bead with a hand grinder.

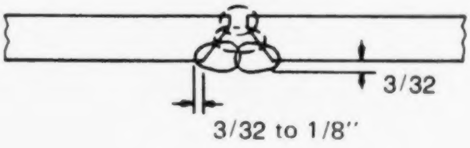
☐ 20. Inspect the root pass for good fusion and penetration and for defects such as undercutting on both outside and inside surfaces.

☐ 21. Adjust amperage to the proper setting for an EXX18 electrode.

☐ 22. Use the EXX18 electrode, and with a drag technique, lay stinger beads for remainder of fill-up, and be sure to clean each pass before starting the next one.

☐ 23. Clean fill-up stringer beads thoroughly.

☐ 24. Use the EXX18 electrode, and with a drag technique, lay cap passes to finish the weld with vertical up welding from 6 to 12 o'clock on each side.



☐ 25. Clean and inspect cap passes.

☐ 26. Have your instructor check your work.

Job Sheet 5

☐ 27. Shut down SMAW equipment.

☐ 28. Conduct a bend test as outlined in Job Sheet 3.

☐ 29. Have your instructor check your bend test.

☐ 30. Check in tools and materials and clean up area.

Evaluator's comments: ______________________________

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Pipe Welding Techniques and Applications
Unit 3

Job Sheet 6—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Vertical Down Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Alignment and gap wire use	______
Tack welds and feathering	______
Quartering technique	______
Restart technique	______
Root pass and cleaning	______
Fill passes and cleaning	______
Cap pass, cleaning, and inspection	______
Bend test	______

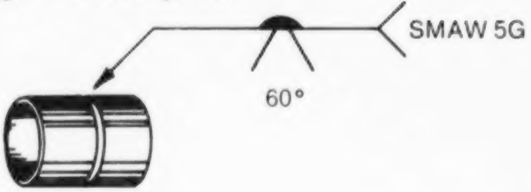
A. Tools and materials

SMAW machine with accessories
Chipping hammer and wire brush
Portable grinder with wire brush
6″ schedule 40 pipe nipples
Electrodes as specified
Gap wire as specified (root opening may vary)
Straightedge or piece of angle iron
Pliers
Personal safety clothing and safety glasses

Job Sheet 6

B. Specifications

1. Joint design and weld symbol:



2. Electrode: EXX10, 3⁄32", 1⁄8"

3. Electrical: DCEP

4. Position: 5G (fixed)

5. Direction: Vertical down

5. Technique: Whip and weave

6. Cleaning: Chip, brush, and grind

7. Testing: Bend test

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Attach ground cable to work table or workpiece.

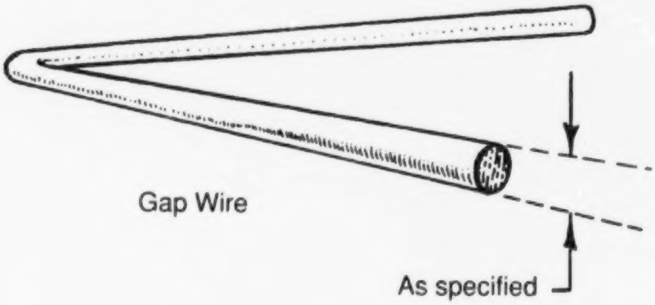
☐ 3. Select correct polarity of electrode.

☐ 4. Turn on SMAW machine.

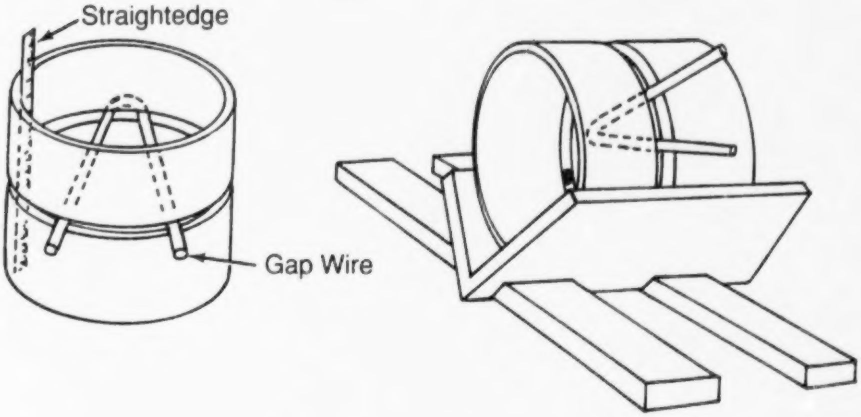
☐ 5. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.

Job Sheet 6

☐ 6. Place two 6″ nipples on work table positioned so that one is on top of the other to form a vertical axis with a proper gap wire placed between the two.



☐ 7. Place a straightedge inside the nipples to align them vertically, or lay the nipples in a piece of angle iron to align them horizontally.



☐ 8. With the EXX10 electrode, tack weld the members in place according to the following procedure:

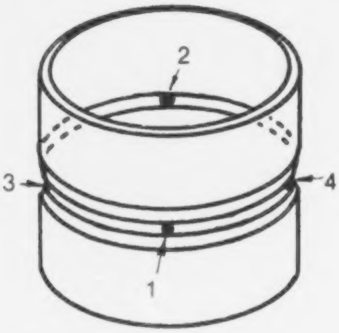
a. Start between the spread ends of the gap wire and make the first tack weld.

b. Move 180° opposite the first tack weld, pull the gap wire out from between the two nipples, use one end of the gap wire to recheck the gap at that point, then make the second tack weld.

c. Move 90° in either direction from the second tack weld and make the third tack weld.

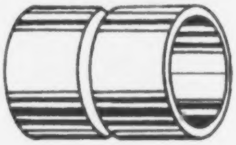
Job Sheet 6

d. Move 180° opposite the third tack weld and make the fourth tack weld.

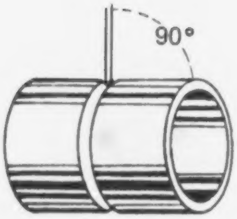


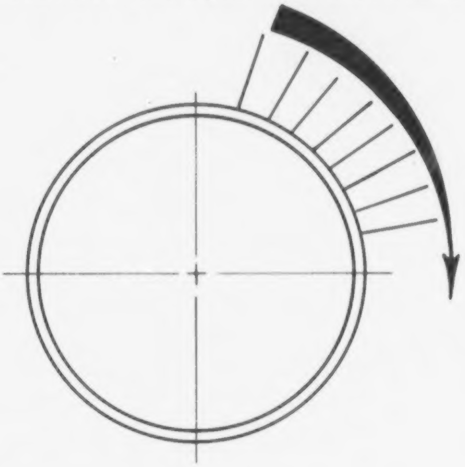
☐ 9. Feather all tack welds with a grinder, but be careful not to grind all the way through the tack weld.

☐ 10. Place the nipples so that they are in the position indicated in specifications.



☐ 11. Place EXX10 electrode in electrode holder and adjust to correct electrode angle.



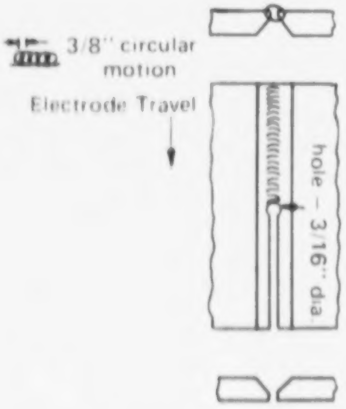


Job Sheet 6

☐ 12. Strike an arc on one of the feathered tacks and quickly adjust to proper arc length.

Caution: Strike the arc only in the weld zone and not on the finished sides of the pipe.

☐ 13. Make a puddle and immediately form a keyhole.



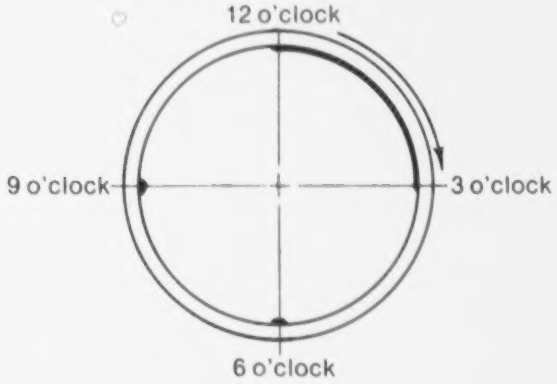
☐ 14. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod back and forth, always move the rod back to the center of the keyhole, and keep electrode arcing in the middle of the joint and not on the outer portion of the bevel.

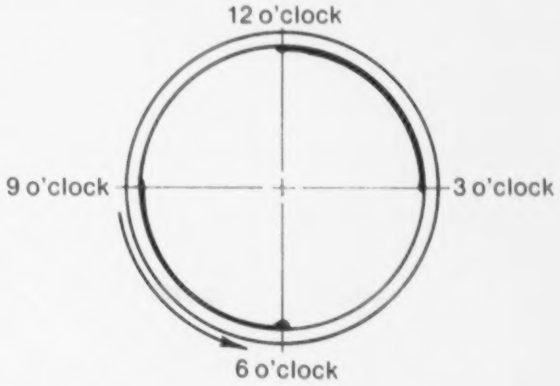
Job Sheet 6

☐ 15. Weld down to the center of the 3 o'clock tack weld and stop at the center point of the tack.

Note: Some procedures permit this pass to be made from 12 to 6 o'clock.

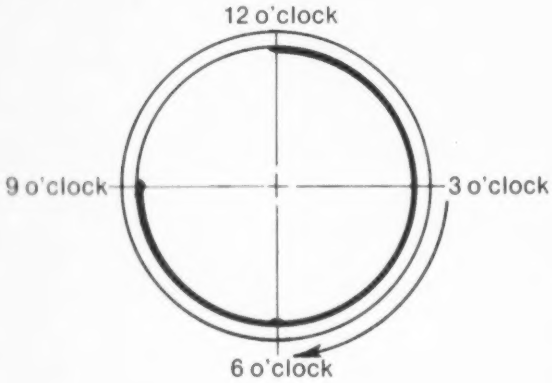

12 o'clock
9 o'clock
3 o'clock
6 o'clock

☐ 16. Restart arc at center of tack weld at 9 o'clock, form proper keyhole, and weld down to the center of the tack weld at 6 o'clock and stop.

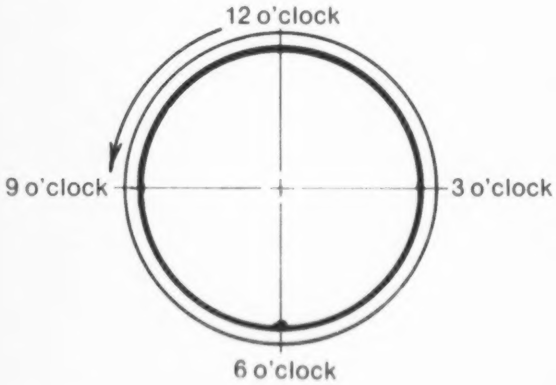

12 o'clock
9 o'clock
3 o'clock
6 o'clock

Job Sheet 6

☐ 17. Go back to the tack weld at 3 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld down to tack weld at three o'clock and tie-in with first quarter pass.



☐ 18. Go back to tack weld at 12 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld down to tack weld at 9 o'clock and tie-in with the first quarter pass.



☐ 19. Chip slag off stringer bead and brush it, or grind the entire bead with a hand grinder.

☐ 20. Inspect the root pass for good fusion and penetration and for defects such as undercutting on both outside and inside surfaces.

☐ 21. Increase amperage setting on SMAW machine, slightly.

☐ 22. Use the same electrode, start at 12 o'clock and weld down with a whipping technique to 6 o'clock for the first half of the hot pass and stop.

Job Sheet 6

☐ 23. Move back to 12 o'clock, restart the arc to tie-in with the first half pass, then weld down the opposite side of the pipe to 6 o'clock and tie-in with the first half to complete the hot pass.

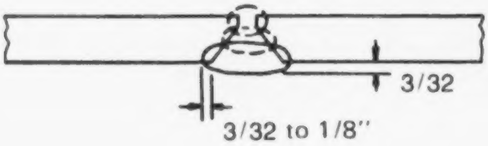
☐ 24. Brush hot pass.

☐ 25. Adjust amperage, if necessary, for EXX10 electrode.

☐ 26. Continue using the EXX10 electrode, with a weaving technique, for remainder of fill-up, and be sure to clean each pass before starting the next one.

☐ 27. Clean fill-up stringer beads thoroughly.

☐ 28. Use the same electrode, and with a weaving technique, lay cap passes to finish the weld with vertical down welding from 12 to 6 o'clock on each side.



☐ 29. Clean and inspect cap passes.

☐ 30. Have your instructor check your work.

☐ 31. Shut down SMAW equipment.

☐ 32. Conduct a bend test as outlined in Job Sheet 3.

☐ 33. Have your instructor check your bend test.

☐ 34. Check in tools and materials and clean up area.

Evaluator's comments: ____________________

____

____

Pipe Welding Techniques and Applications
Unit 3

Job Sheet 7—Weld to Specifications a V-Groove Butt Joint on 6″ Schedule 40 Pipe in the Vertical Down, 45° Inclined Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and safety	______
Alignment and gap wire use	______
Tack welds and feathering	______
Quartering technique	______
Restart technique	______
Root pass and cleaning	______
Fill passes and cleaning	______
Cap pass, cleaning, and inspection	______
Bend test	______

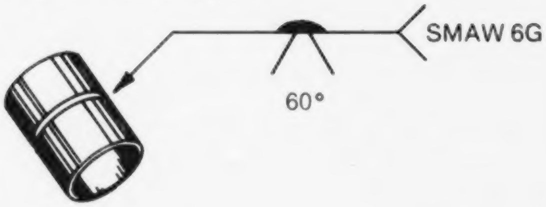
A. Tools and materials

SMAW machine with accessories
Chipping hammer and wire brush
Portable grinder with wire brush
6″ schedule 40 pipe nipples
Electrodes as specified
Gap wire as specified (root opening may vary)
Straightedge or piece of angle iron
Pliers
Personal safety clothing and safety glasses

Job Sheet 7

B. Specifications

1. Joint design and weld symbol:



2. Electrode: EXX10, 3/32", 1/8"

3. Electrical: DCEP

4. Position: 6G (fixed)

5. Direction: Vertical down

5. Technique: Whip and weave

6. Cleaning: Chip, brush, and grind

7. Testing: Bend test

C. Procedure

☐ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

☐ 2. Attach ground cable to work table or workpiece.

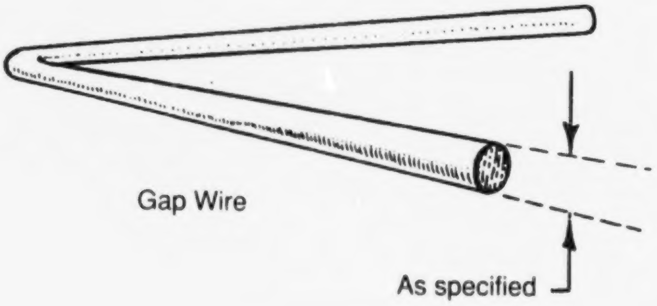
☐ 3. Select correct polarity of electrode.

☐ 4. Turn on SMAW machine.

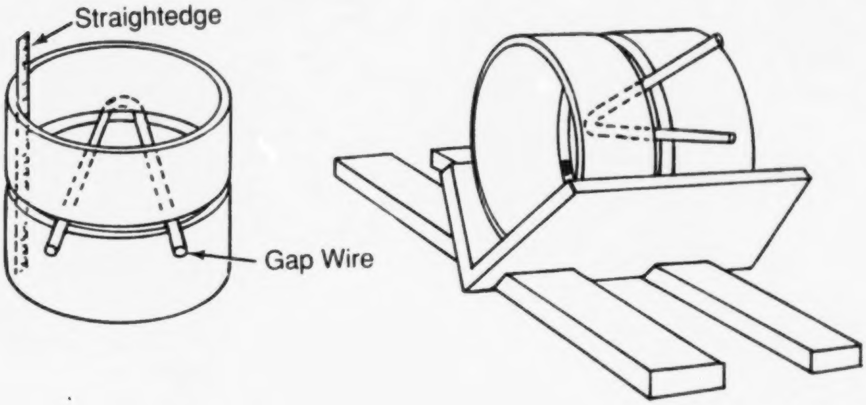
☐ 5. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.

Job Sheet 7

☐ 6. Place two 6" nipples on work table positioned so that one is on top of the other to form a vertical axis with a proper gap wire placed between the two.



☐ 7. Place a straightedge inside the nipples to align them vertically, or lay the nipples in a piece of angle iron to align them horizontally.



☐ 8. With the EXX10 electrode, tack weld the members in place according to the following procedure:

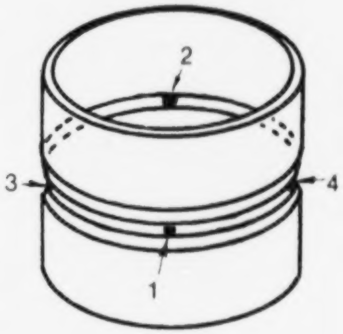
   a. Start between the spread ends of the gap wire and make the first tack weld.

   b. Move 180° opposite the first tack weld, pull the gap wire out from between the two nipples, use one end of the gap wire to recheck the gap at that point, then make the second tack weld.

   c. Move 90° in either direction from the second tack weld and make the third tack weld.

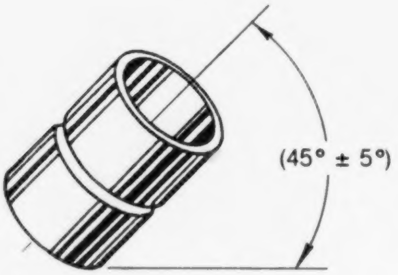
Job Sheet 7

d. Move 180° opposite the third tack weld and make the fourth tack weld.

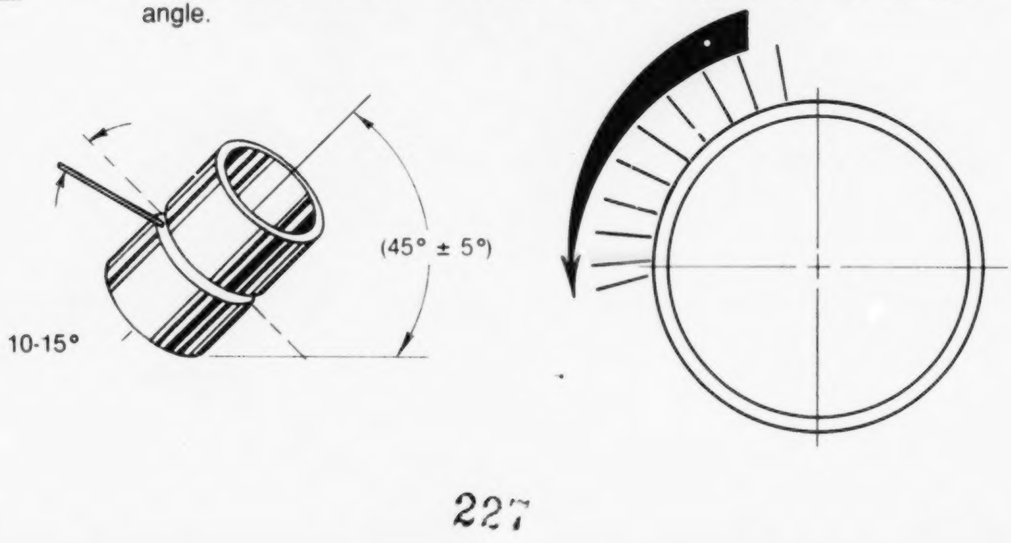


☐ 9. Feather all tack welds with a grinder, but be careful not to grind all the way through the tack weld.

☐ 10. Place the nipples so that they are in the position indicated in specifications.



☐ 11. Place EXX10 electrode in electrode holder and adjust to correct electrode angle.

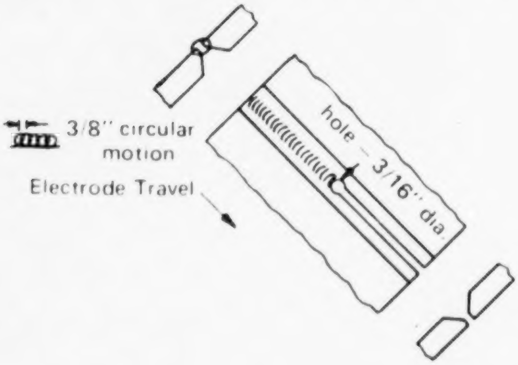


Job Sheet 7

☐ 12. Strike an arc on one of the feathered tacks and quickly adjust to proper arc length.

Caution: Strike the arc only in the weld zone and not on the finished sides of the pipe.

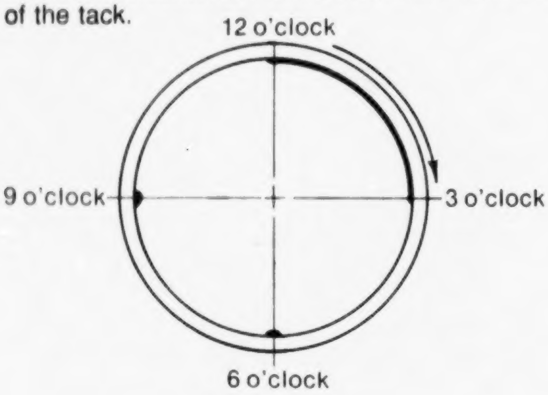
☐ 13. Make a puddle and immediately form a keyhole.


3/8" circular motion
Electrode Travel
hole – 3/16" dia.

☐ 14. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

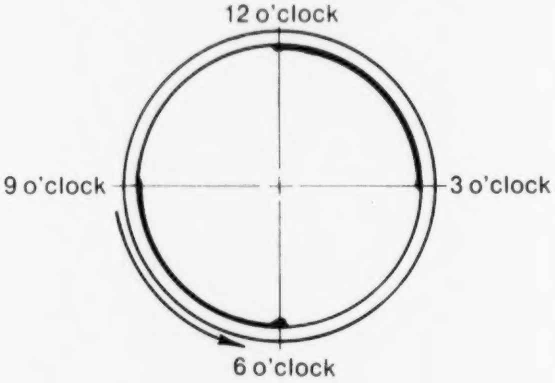
Note: Do not deposit filler metal outside the keyhole as you whip the rod back and forth, always move the rod back to the center of the keyhole, and keep electrode arcing in the middle of the joint and not on the outer portion of the bevel.

☐ 15. Weld down to the center of the 3 o'clock tack weld and stop at the center point of the tack.

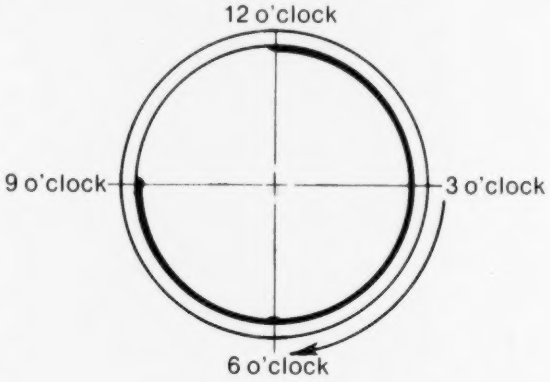

12 o'clock
9 o'clock
3 o'clock
6 o'clock

Job Sheet 7

☐ 16. Restart arc at center of tack weld at 9 o'clock, form proper keyhole, and weld down to the center of the tack weld at 6 o'clock and stop.

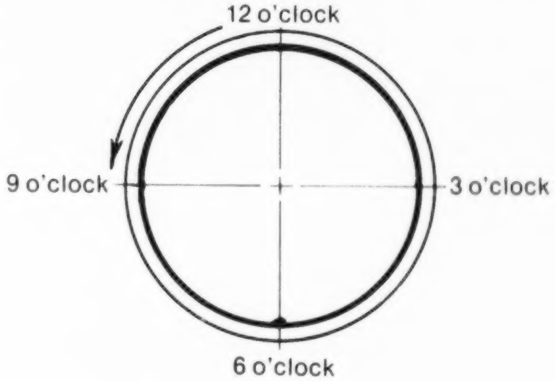

12 o'clock
9 o'clock
3 o'clock
6 o'clock

☐ 17. Go back to the tack weld at 3 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld down to tack weld at 6 o'clock and tie-in with first quarter pass.


12 o'clock
9 o'clock
3 o'clock
6 o'clock

Job Sheet 7

☐ 18. Go back to tack weld at 12 o'clock, restart arc to tie-in with previous quarter pass, form proper keyhole, and weld down to tack weld at 9 o'clock and tie-in with the first quarter pass.



☐ 19. Chip slag off stringer bead, brush it, then grind the entire stringer bead with a hand grinder.

☐ 20. Inspect the root pass for good fusion and penetration and for defects such as undercutting on both outside and inside surfaces.

☐ 21. Increase amperage setting on SMAW machine slightly.

☐ 22. Use the same electrode, start at 12 o'clock and weld down with a whipping technique to 6 o'clock for the first half of the hot pass and stop.

☐ 23. Move back to 12 o'clock, restart the arc to tie-in with the first half pass, then weld down the opposite side of the pipe to 6 o'clock and tie-in with the first half to complete the hot pass.

☐ 24. Brush hot pass.

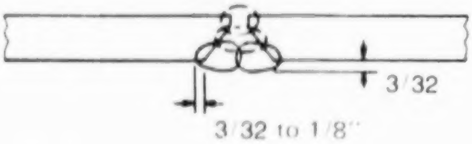
☐ 25. Adjust amperage if necessary.

☐ 26. Continue using the EXX10 electrode, and lay stringer beads for remainder of fill-up, and be sure to clean each pass before starting the next one.

☐ 27. Clean fill-up stringer beads thoroughly.

Job Sheet 7

☐ 28. Use the same electrode, and with a stringer technique, lay cap passes to finish the weld with vertical down welding from 12 to 6 o'clock on each side.



☐ 29. Clean and inspect cap passes.

☐ 30. Have your instructor check your work.

☐ 31. Shut down SMAW equipment.

☐ 32. Conduct a bend test as outlined in Job Sheet 3.

☐ 33. Have your instructor check your bend test.

☐ 34. Check in tools and materials and clean up area.

Evaluator's comments: ____

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